MISCELLANEOUS PAPER NO. 4-852

EVALUATION OF HARVEY TWO-PIECE LANDING MAT (AM2)

by

C. D. Burns
W. R. Barker

November 1966

Sponsored by

Naval Air Engineering Center
Philadelphia, Pennsylvania

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

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FOREWORD

This report is the 14th in a series published on landing mat tests performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the Naval Air Engineering Center (NAEC), Philadelphia, Pa. The investigation reported herein was authorized by the NAEC in Project Order No.6-4031, dated 3 December 1965, and was conducted by the WES during February 1966.

Engineers of the WES Soils Division who were actively engaged in the planning, testing, analyzing, and reporting phases of this investigation were Messrs. R. G. Ahlvin, C. D. Burns, W. R. Barker, and M. J. Mathews, under the general supervision of Messrs. W. J. Turnbull and A. A. Maxwell, Chief and Assistant Chief, respectively, of the Soils Division. This report was prepared by Messrs. Burns and Barker.

Colonel John R. Oswalt, Jr., CE, was Director of the WES during the conduct of this investigation and the preparation of this report. Mr. J. B. Tiffany was Technical Director.

CONTENTS

SUMMARY

This investigation was conducted to evaluate a so-called two-piece landing mat (AM2) extruded and fabricated by Harvey Aluminum Co., Inc., Torrance, Calif. The mat was fabricated from two 1-ft-wide extrusions welded together to form a 2-ft-wide plank.

A test section consisting of three clay subgrade items (with strengths of 3, 6, and 10 CBR) and one loosely compacted sand item was constructed and surfaced with the two-piece mat. The test section was subjected to uniform and single-line traffic representing operations of an aircraft having a 60,000-lb gross weight with a single-wheel main gear assembly load of 27,000 lb and a 30-7.7 tire inflated to 400 psi.

Based on the results obtained in this study, it is concluded that:

a. The Harvey aluminum two-piece mat (AM2) will sustain 1600 operational cycles (188 coverages) of aircraft having a 27,000-lb single-wheel load and 400-psi tire-inflation pressure when the mat is placed on a subgrade having a CBR of 6.2 or greater throughout the period of traffic.

b. The Harvey aluminum two-piece mat will sustain 1600 passes in a single path located 2 ft or more away from the mat end joints of a 27,000-lb single-wheel load with a tire-inflation pressure of 400 psi when the mat is placed on a subgrade having a CBR of 5.1 or greater throughout the period of traffic.

c. General behavior of the mat in these tests was not materially affected by the two-piece nature of the mat panels.

EVALUATION OF HARVEY TWO-PIECE LANDING MAT (AM2)

PART I: INTRODUCTION

Background

1. For several years the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., has been engaged in a study for the Naval Air Engineering Center (NAEC), Philadelphia, Pa., for the purpose of evaluating various types of landing mats to be used in surfacing small airfields for tactical support (SATS) in combat air operations. A SATS has been defined as a small, quickly constructed, temporary, tactical support airfield, capable of sustaining operations of the Marine Corps' modern jet aircraft which employ assisted takeoffs and arrested landings.

2. The service criterion established by NAEC for landing mat is that it remain in serviceable condition with minimum maintenance for at least 1600 aircraft operation cycles during a 30-day period when placed on a subgrade having a CBR of 10 or less. (A cycle is one takeoff and one landing.) The heaviest proposed Marine Corps aircraft that will utilize SATS weights 60,000 lb (27,000 lb per main gear wheel) and is equipped with 30-7.7, 18-ply rating tires inflated to 400 psi. Therefore, for the evaluation of various landing mats considered for use in SATS, NAEC has standardized the test load at 27,000 lb on a single wheel with a 30-7.7, 18-ply tire inflated to 400 psi. NAEC requires that a test section of the particular mat under consideration when placed on a subgrade having a CBR of 10 or less remain serviceable with minimum maintenance (a) for 188 coverages (equivalent to 1600 cycles) of the test load applied uniformly over a 10-ft-wide traffic lane, and (b) for 1600 passes of the test load applied in a single path (one tire print width). The uniform-coverage traffic simulates landings and normal takeoffs in which no catapult is used, and the single-path traffic simulates takeoff runs in which a catapult system is employed.

3. Early in the test program, an aluminum landing mat developed by the Harvey Aluminum Co. (hereinafter referred to as Harvey), Torrance,

Calif., and tested at WES, fulfilled the test requirements noted above (see WES Miscellaneous Paper No. 4-615 Development of CBR Design Curves for Harvey Aluminum Landing Mat, dated January 1964). Subsequently, the design for the Harvey mat was standardized by NAEC, and the mat was designated Airfield Matting No. 2 (AM2). Several tests have been conducted at WES on small lots of AM2 fabricated under different procurement contracts (see report titles listed on inside of front cover of this report). Although there has been considerable variation in the test performance of the AM2 fabricated by the various manufacturers, all the mats tested have met minimum performance standards. However, the results of a later test of Harvey AM2 with a modified end joint connector indicated that the modified mat was superior to the previously standardized AM2. Therefore, NAEC incorporated the modified end joint detail into its specifications for future AM2 procurements.

4. All previous AM2 tested at WES was constructed from a single aluminum extrusion approximately 2 ft wide, which was cut into 12-ft lengths onto which the end joint connectors were welded to form a plank. Although the single-extrusion process facilitates plant fabrication of the mat, the number of mat manufacturers in the United States capable of producing extrusions of this size is limited. Thus, even though the multiextrusion mat requires a more complicated fabrication process than the single-extrusion mat, the use of narrow extrusions would permit a greater number of manufacturers to produce the mat and thus potentially increase the sources of AM2.

5. For this investigation, the NAEC procured small quantities of AM2 fabricated by Harvey from two 1- by 12-ft extrusions (from whence the term "two-piece" was derived) welded together to form a single 2- by 12-ft panel.

Objective and Scope of Investigation

6. The objective of this investigation was to evaluate the performance of Harvey two-piece AM2 under accelerated traffic tests with loadings contemplated under the SATS concept.

7. The objective was accomplished by:

<u>a</u>. Constructing a test section that consisted of different subgrade materials and strengths, and surfacing the section with Harvey two-piece aluminum landing mat.

<u>b</u>. Performing accelerated traffic tests with a 27,000-lb single-wheel load on a 30-7.7, 18-ply tire inflated to 400 psi.

<u>c</u>. Observing the behavior of the mat and subgrade during traffic tests and recording pertinent test data.

<u>d</u>. Analyzing the performance data from the two-piece mat test and comparing the test results with the criteria established by NAEC for AM2.

This report describes the landing mat, test section, tests conducted, results obtained, and presents an analysis of the test data.

Definition of Traffic Terms

8. Traffic terms having a special meaning in this report are defined below:

<u>a</u>. <u>Cycle.</u> A cycle is one takeoff and one landing of an aircraft. For this test, a cycle is considered one round trip or two passes of the test vehicle over the mat.

<u>b</u>. <u>Pass.</u> A pass is one traverse of a load wheel along a given length of runway, taxiway, or test section surface. In this investigation, load repetitions applied in a single path (one tire print width) are referred to as passes. The repetitious loads resulting from aircraft taking off over the same path when a catapult system is used are simulated on a test section by the application of the test load in repeated passes along a single line or path, e.g. 1600 cycles of an aircraft involves 1600 takeoffs or 1600 passes over the same path.

<u>c</u>. <u>Coverage.</u> One coverage consists of one application of the wheel of an aircraft or test load vehicle over the entire area of the test lane being subjected to traffic. Since the traffic is applied incrementally in passes, and the width of each pass is equal to one tire print width, the number of passes required to complete one coverage is equal to the test lane width divided by the tire print width.

PART II: TEST SECTION, MAT, AND TEST LOAD CART

Test Section

Location

9. The traffic tests were conducted at the WES on a special test section which was constructed and subjected to traffic under shelter in order to control water content and strength of the subgrade soil.

Description

10. A layout of the test section is shown in plate 1. The test section was approximately 150 ft long and 24 ft wide and consisted of four test items. Items 1, 2, and 3 were each approximately 40 ft long and item 4 was approximately 30 ft long. The subgrades of items 1, 2, and 3 were constructed of a heavy clay soil; the subgrade of item 4 was constructed of a loose sand. Classification data for the subgrade soils are shown in plate 2.

Subgrade construction

11. The test subgrades were to be constructed to a total thickness of 24 in.; therefore, the existing material at the test site was excavated to a depth of 24 in. below finished grade, and the excavation was backfilled with the special test soils. The soil at the bottom of the excavation was a lean clay having an approximate CBR value of 10. The subgrades for items 1, 2, and 3 were to be constructed of the heavy clay soil at water contents that would result in CBR values of approximately 3, 6, and 10, respectively, after compaction. The soil for each test item was processed separately to the desired water content, hauled to the test site by truck, spread, and compacted in 6-in.-thick lifts. Compaction of each lift was accomplished by applying eight coverages of a four-wheel, rubber-tired roller loaded to 40,000 lb with its tires inflated to 90 psi. The surface of each lift was scarified prior to the placement of the next lift. After placement and compaction of the fourth and final lift, the surface of the subgrade was fine-bladed to grade by a motor patrol. Item 4 consisted of a 24-in. thickness of loose sand. The sand was end-dumped from trucks, spread, and compacted in a single lift with only a few

coverages of a D4 tractor. The sand was left slightly crowned and higher than the other items, as considerable settlement under traffic was anticipated.

Mat

Description

12. A total of 14 bundles of two-piece AM2 was received at WES. Each bundle consisted of 11 full and 2 half planks. The mat planks had been fabricated from two separate extrusions approximately 1 ft wide which had been fitted and welded together to form a mat plank approximately 2 ft wide. End connector strips were also welded onto the ends of the extrusions. The top surface of the mat was coated with an antiskid compound. The average dimensions and weights of the mat planks were as follows:

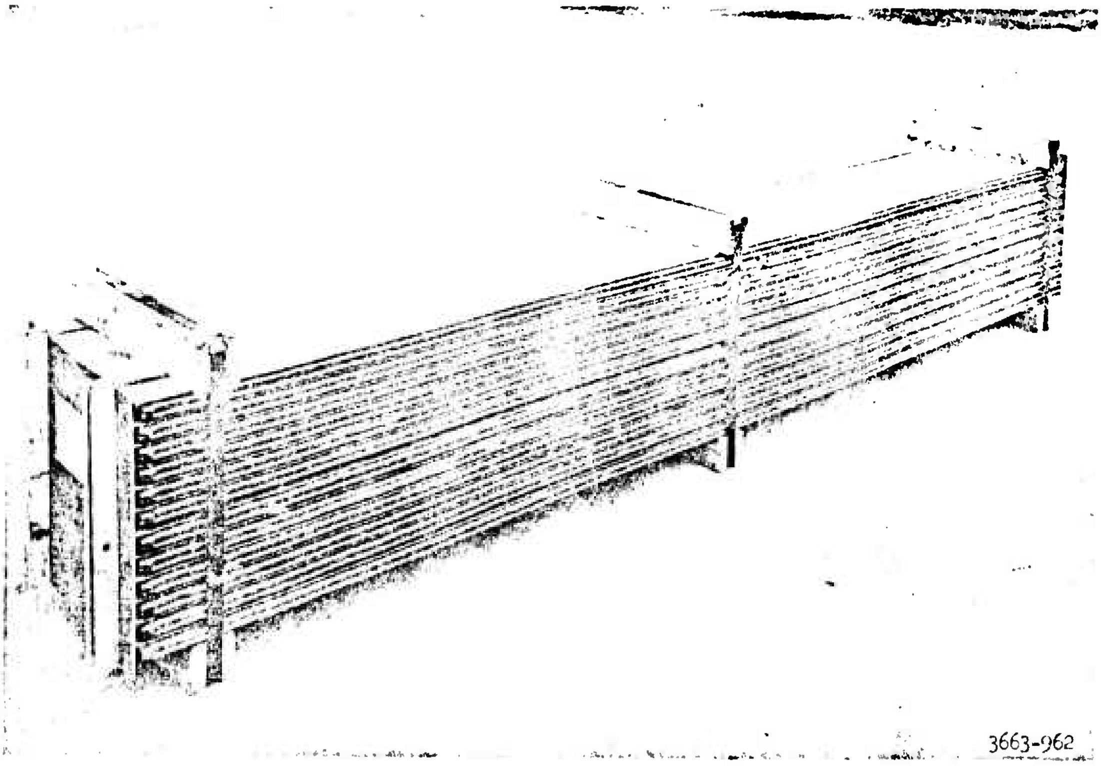
Plank	Width ft	Length ft	Thickness in.	Weight lb	Weight psf
Full	2	12	1-1/2	150	6.2
Half	2	6	1-1/2	76.5	6.4

A mat bundle is shown in fig. 1a, and a whole and half mat plank are shown in fig. 1b.

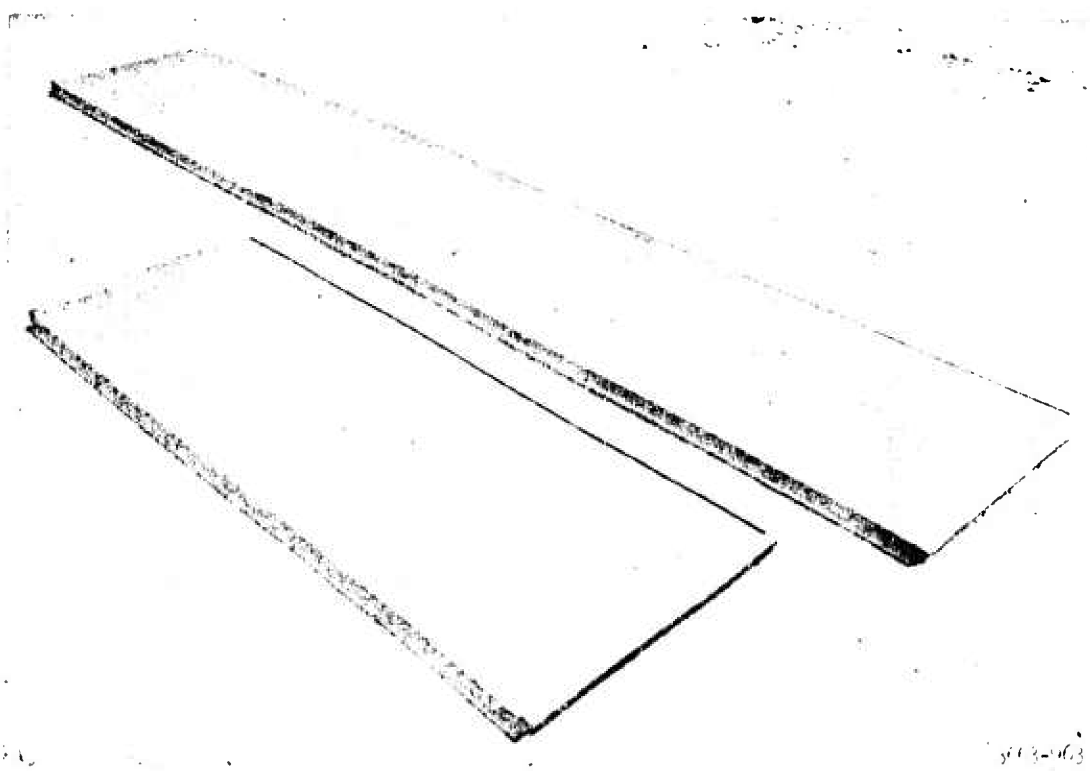
Placement procedures

13. The mat was placed on the test section by a crew of experienced laborers under the supervision of a foreman. The mat bundles were placed alongside the test section with a forklift, and the individual planks were carried a distance of about 30 ft by laborers and placed in position. One laborer inserted end-connecting rods between the planks at the end joints. Although the placement of the two-piece extrusion mat was not timed, the average placing time for the AM2 is approximately 225 sq ft per man-hour.

14. The entire test section was surfaced with Harvey two-piece AM2. The planks were placed with the long axis perpendicular to the direction of traffic (plate 1). The surfaced test section was approximately 24 ft wide. The first run of mat consisted of two full planks



a. Bundle



b. Full and half plank

Fig. 1. Bundle and planks of Harvey two-piece AM2

placed end-to-end, and the second run consisted of one full plank in the center with half planks on both ends. This alternating pattern was continued throughout the test section for 75 runs, or approximately 150 ft and provided the staggered joint configuration shown in plate 1. Items 1, 2, and 3 each were surfaced with 20 runs of mat, and item 4 was surfaced with 15 runs of mat.

Test Load Cart

15. A specially designed single-wheel test cart (fig. 2) loaded

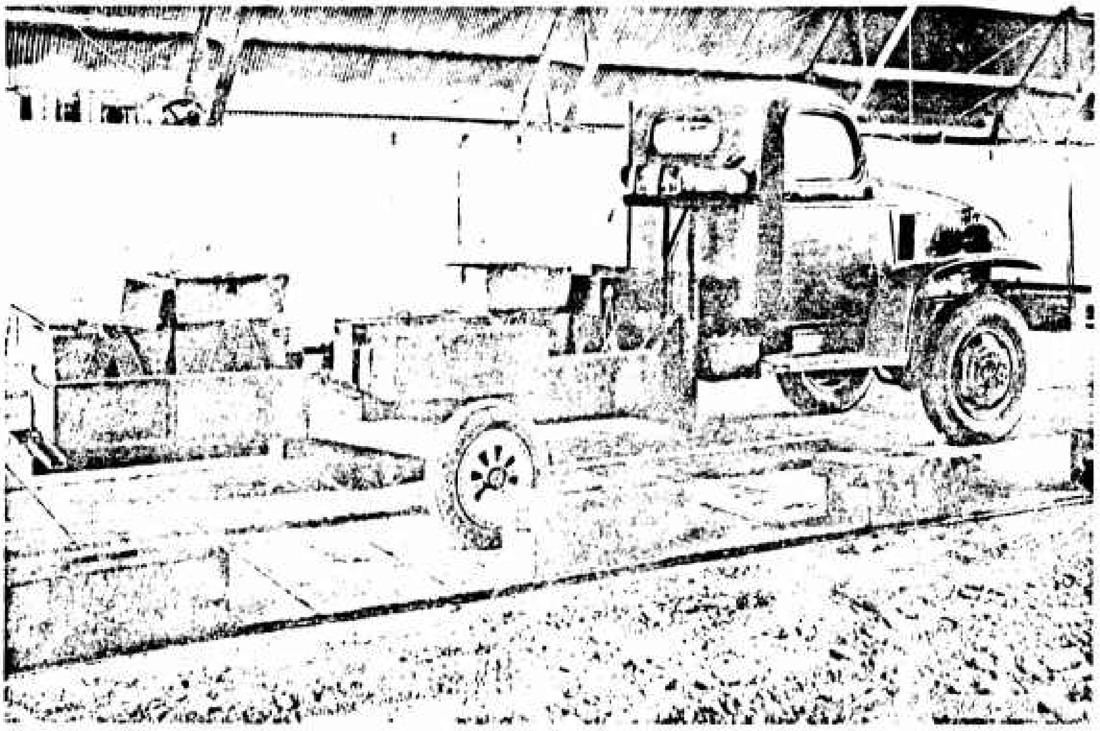


Fig. 2. Test load cart, 27,000-lb single-wheel load with tire inflated to 400 psi

to 27,000 lb was used in the traffic tests. It was equipped with an outrigger wheel to prevent overturning and was powered with the front half of a four-wheel drive truck. The test wheel was equipped with a 30-7.7, 18-ply rating tire inflated to 400 psi. With the 27,000-lb wheel load, the tire had a contact area of about 82 sq in. and an average contact pressure of 330 psi.

PART III: TESTS AND RESULTS

Traffic Tests

Uniform-coverage traffic

16. Uniform-coverage traffic was applied in a 10-ft-wide traffic lane designated lane 1 (plate 1) to simulate the repetitious application of a main landing gear wheel on a mat surface which would occur during landings and normal takeoffs with no catapult used. Traffic was applied by driving the load cart forward and backwards over the length of the test section, shifting the path of the cart laterally about 7.3 in. (one tire-print width) on each forward pass. This procedure resulted in two complete coverages of traffic on the test lane each time the load cart was maneuvered from one side of the lane to the other. Traffic was continued until the mat in each test item failed, or until a total of 188 coverages had been completed, whichever occurred first.

Single-line traffic

17. In aircraft launching operations employing a Corps of Engineers' type catapult, all aircraft are launched from the same position on the runway, and the wheels of each aircraft follow essentially the same path on each takeoff. To simulate this type of loading, traffic was applied in a single path on a line approximately 3 ft east of the east edge of the uniform-coverage traffic lane as shown in plate 1. Traffic was applied until each item failed or until 1600 passes had been completed, whichever occurred first.

Soil Tests and Miscellaneous Observations

18. Water content, density, and in-place CBR tests were conducted prior to and after the traffic tests of each item had been completed. These tests were made at depths of 0, 6, and 12 in. At least three tests were made at each depth, and the data obtained from the tests are summarized in table 1. The values listed in table 1 corresponding to the various depths are averages of the three values measured at each particular depth.

19. Pertinent data and visual observations of the behavior of the test items were recorded throughout the traffic test period. These data and observations were supplemented by photographs. Level readings were taken on the mat prior to and at intervals during traffic to show the development of permanent mat deformation and elastic deflection of the mat under the wheel load.

Behavior of Mat Under Traffic

Failure criteria

20. The criteria for mat failure were the same as those previously used in other tests of this series. These failure criteria were based primarily on mat breakage. It was assumed that a certain amount of maintenance could be performed in the field during actual usage, and that minor metal or weld breaks could be easily repaired. However, in this test, when an end connector broke off or a mat core collapsed, the mat plank was considered to have failed and required replacement. Partial core failures did not immediately result in an unserviceable plank, but in some cases the failure progressed to the point that the plank became a tire hazard and had to be considered a complete failure. It was considered feasible to replace up to 10 percent of the mat planks with new mat during the design service life of the runway, but the maintenance effort to replace more than 10 percent of the planks was considered excessive. Therefore, for the test section, it was assumed that up to 10 percent of the mat planks could be replaced; when an additional 10 percent (a total of 20 percent) of the planks had failed, the entire test item was considered failed.

Test lane 1, uniform-coverage traffic

21. Visual observations. A general view of the test lane prior to traffic is shown in photograph 1. The first defect to show up in the mat was a hairline crack in the weld of an underlapping end connector strip on one plank in test item 3. This crack was noted after two coverages. After 14 coverages, several small weld cracks were noted at the corner of the end connector strips on several planks in test item 1. These

cracks developed quite rapidly as traffic continued, and by the end of 40 coverages, the end joints on three planks in test item 1 had completely failed. A close-up of a joint failure on plank 29 is shown in fig. 3. A general view of test item 1 after 40 coverages is shown in photograph 2.

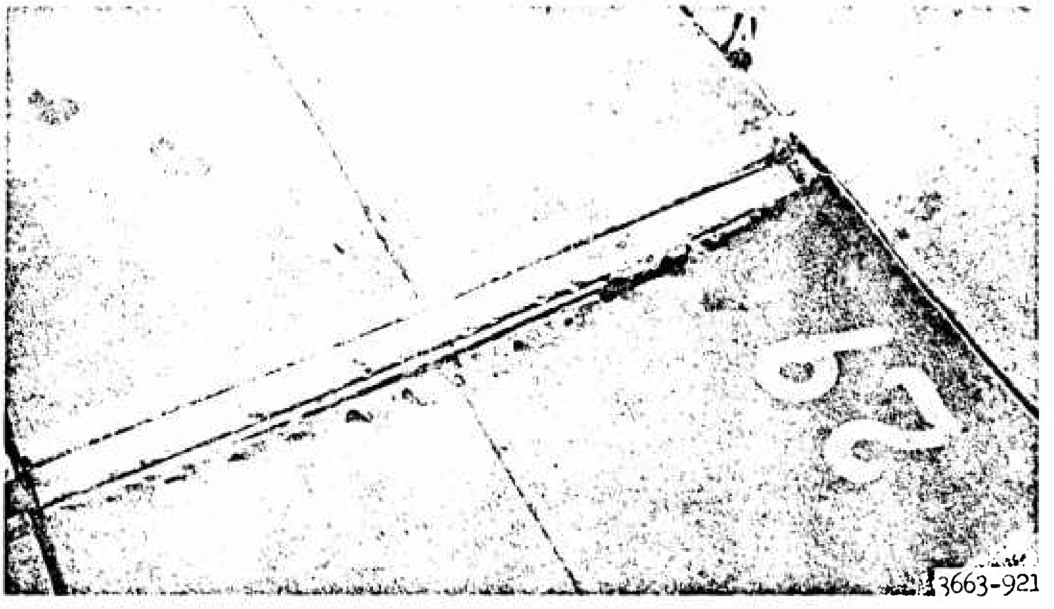


Fig. 3. Typical end-joint failure

22. The mat in all other test items was in good condition after 40 traffic coverages. However, slight weld cracks were noted at the end connectors of three planks in test item 2. Also, the cracks that developed early in the underlapping end connector strip of one plank in test item 3 had progressed across the full width of the plank. However, the top portion of the weld held, and the joint did not present a hazard. The three failed planks in test item 1 were replaced at the end of 40 coverages, and traffic was continued.

23. By the time 70 coverages of traffic had been completed, three additional planks had failed in test item 1, making a total of 6 failed planks or 20 percent of the planks undergoing tests. Two of these failures were end-joint failures similar to that shown in fig. 3. The other was a longitudinal weld failure as shown in fig. 4. A general view of test item 1 after 70 coverages is shown in photograph 3. Since 20 percent of

the mat planks in this item had failed, no further traffic was applied.

24. One end connector joint of a plank in item 2 failed after about 56 traffic coverages. This plank was replaced at the end of 70 coverages, and traffic was continued on test items 2, 3, and 4. At the completion of 100 coverages, two additional end connector joints had failed in test item 2 and were replaced. Cracks in longitudinal welds of two mat planks were also noted. However, they did not appear to have any adverse effect on mat performance. After 130 coverages, three additional end joint failures had developed, making a total of 20 percent of failed planks in the item. At this time, traffic on item 2 was discontinued. A general view of test item 2 at the end of 130 coverages is shown in photograph 4. All of the failures in item 2 were of the same type; the weld between the end connector strip and the body of the plank failed, allowing the end connector to separate from the plank.

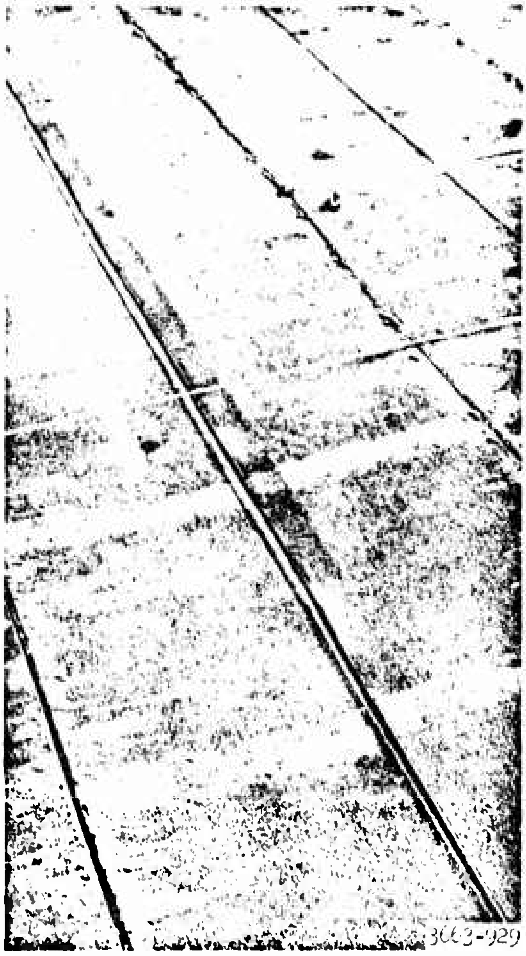


Fig. 4. Lane 1, item 1, longitudinal weld failure after 70 coverages

25. The mat in test items 3 and 4 was in good condition after 130 coverages except for one end connector joint failure in item 3. Traffic was continued for the full 188 coverages on these two items with no further failures developing. General views of items 3 and 4 after 188 coverages are shown in photographs 5 and 6, respectively.

26. Permanent deformation. Plots showing permanent deformation of

the mat as determined from level readings taken prior to and at various stages of traffic in test lane 1 are shown in plates 3 and 4. The center-line profiles in plate 3 illustrate mat deformation down the center of each test item. Since the mat was laid in a staggered pattern, every other run of mat consisted of two whole planks with an end joint located at the center line of the traffic lane. As can be noted in plate 3, the mat surface remained relatively smooth down the center line of all test items with the exception of a few abrupt depressions in items 1 and 2. These depressions were the results of end-joint failures in the mat planks. The overall deformation in test items 1, 2, and 3 (the clay subgrade) is very minor. However, permanent deformation varying from 0.5 to 1.5 in. is indicated for the mat over the sand subgrade in test item 4. As can be noted in the profile, most of this deformation occurred during the first 20 coverages of traffic, and was caused by the consolidation of the loose sand subgrade.

27. Typical cross sections showing mat deformation across the traffic lane are shown in plate 4. These data show about the same pattern of deformation as do the profiles.

28. Mat deflection. Plots of mat deflection under load, as determined from level readings, are shown in plate 5. These data indicate the elastic deflection, or rebound, of the mat as the load wheel moved over the surface. Plots are shown for the load wheel centered over an end joint between two mat planks and on the center of a mat plank. Deflection data are shown for 0 coverages at the beginning of traffic and for the coverages at which traffic was terminated. The data show no significant differences in deflection with respect to the point of loading, i.e. over an end joint or over the center of a mat plank. For the clay subgrade items, the deflection decreased as the subgrade strength increased. The average maximum deflection for test items 1, 2, and 3 at the end of traffic was about 1.0, 0.9, and 0.6 in., respectively. In test item 4 (the sand subgrade) the greatest deflection occurred at the end of traffic with a maximum deflection of about 1.4 in. This relatively high mat deflection was caused by consolidation of the initially loose sand and bridging of the mat over the sand subgrade in the traffic lane.

Test lane 2, single-line traffic

29. Visual observations. A general view of the single-line traffic lane prior to traffic is shown in photograph 7. Severe flexing of the mat on items 1 and 4 was noted from the beginning of traffic. The first mat distress noted occurred at 310 passes when the longitudinal weld of a plank in item 1 developed a crack across the width of the traffic lane. Core damage was first noted in a plank of item 1 after 600 passes. During traffic, horizontal shifting of the mat developed (photograph 8); the shifting was greatest on items 1 and 4, which required realignment at various intervals during traffic. Also visible in photograph 8 is a longitudinal weld in plank 3 which cracked after 310 passes. By 600 passes, longitudinal weld cracks had developed in three mat planks, and indications of core damage were evident in one plank. By 1000 passes, the mat surface in item 1 was very rough and core failure had developed in seven mat planks, at which time the item was considered failed. At failure, the mat surface had rutted and deformed in the traffic path (photograph 9). This deformation caused the east edge of the mat to project up approximately 3 in. off the subgrade (photograph 10).

30. Some mat distress was noted in test items 2 and 4 at the end of 1000 passes, but little or no distress was noted in test item 3. Views of items 2, 3, and 4 at the end of 1000 passes of the load wheel are shown in photographs 11, 12, and 13, respectively. As traffic was continued, rapid deterioration of the mat in items 2 and 4 developed between 1200 and 1600 passes, and these items were considered failed after 1600 passes of traffic. The mat in item 3 was still in good condition when traffic was terminated. Test items 2, 3, and 4 at the end of traffic (1600 passes) are shown in photographs 14, 15, and 16, respectively. A typical longitudinal weld crack and dished planks indicating core failure are shown in fig. 5. One plank from each of the items was cut on the traffic lane center line. A cross-section view of each of these is shown in fig. 6. In the figure, planks 1, 2, 3, and 4 are from items 1, 2, 3, and 4, respectively, and are representative of the comparative damage suffered by each item by the end of traffic. It can be seen that the bottom weld had cracked in planks 2 and 4, whereas the top was still in good

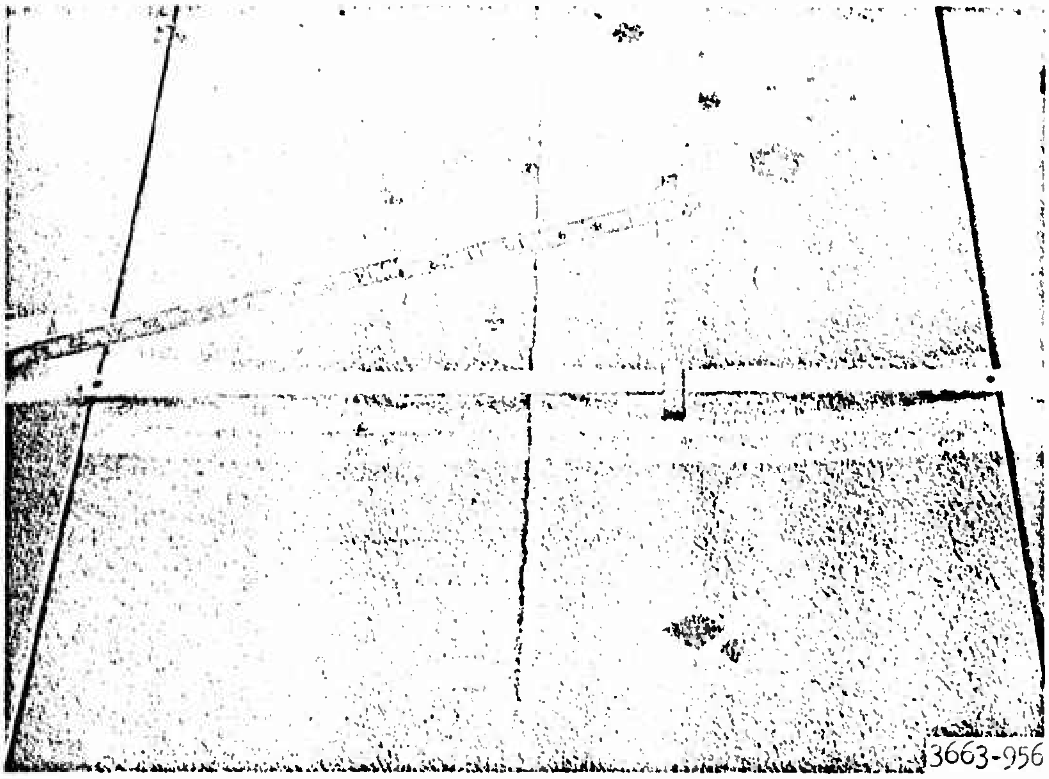


Fig. 5. Lane 2, item 2. Longitudinal weld failure and depression indicating core failure

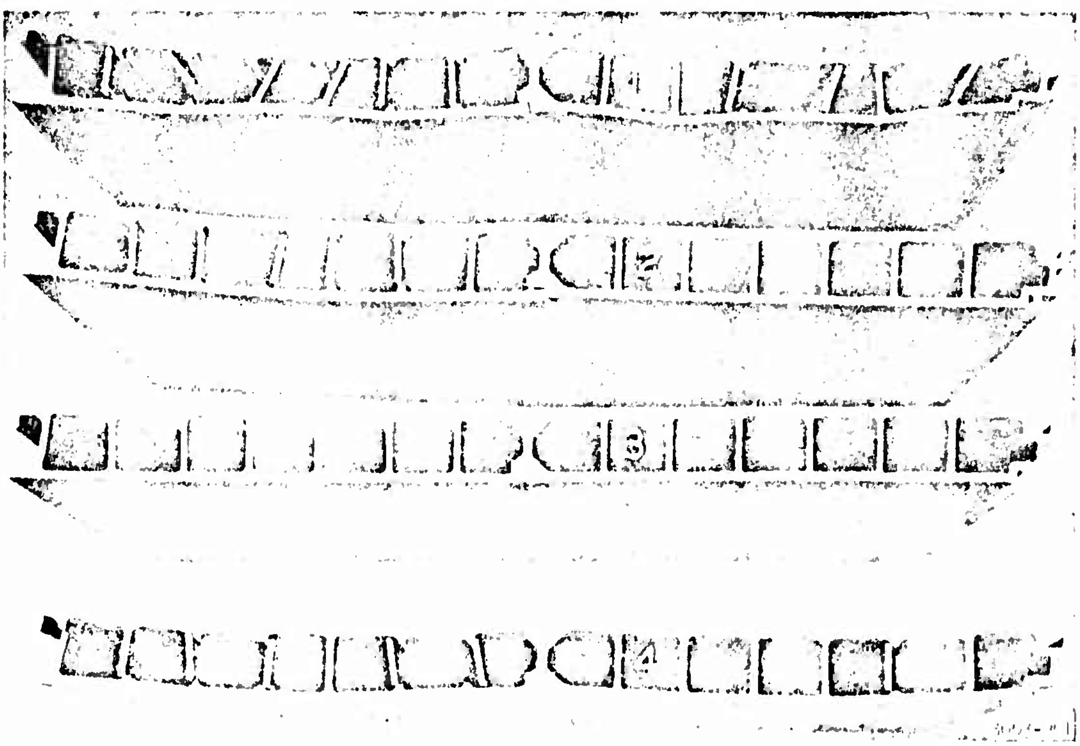


Fig. 6. Cross-section views of typical planks from items 1-4. Sections cut from center line of traffic lane after single-line traffic

condition. In all of the planks, the center weld member was still undamaged, and the ribs on the female side of the center web had sustained the most damage.

31. Permanent deformation. Profile plots showing permanent deformation along the center of the traffic path for items 1, 2, 3, and 4 of test lane 2 are shown in plate 6. These plots show that the mat surface in all test items remained relatively smooth for the first 600 passes of the load wheel, but by the end of traffic the mat was quite rough in items 1, 2, and 4 where core failures had occurred. The actual deformation was relatively small in all items except item 4 (the sand subgrade). The indicated deformation in this item of from 1 to 1-1/2 in. was caused by the consolidation of the sand which was initially placed in a loose condition.

32. Cross-section plots of permanent mat deformation across the traffic path at various traffic intervals are shown in plate 7. These plots indicate the severe bending and mat deformation that developed in test items 1, 2, and 4, as previously discussed (paragraphs 29, 30, 31), and also, the absence of deformation in test item 3.

33. Mat deflection. Typical plots showing the elastic deflection of the mat under the wheel load in the test items in lane 2 are shown in plate 8. These data show that for items 1, 2, and 4, the deflection at the end of traffic was somewhat greater than at the start of traffic. However, for test item 3, the mat deflection remained about constant throughout the period of traffic.

Summary and Analysis of Test Results

Test lane 1, uniform-coverage traffic

34. Analysis. A summary of the test results for the 27,000-lb single-wheel load traffic applied uniformly over the 10-ft-wide traffic lane is shown in table 2, which presents the rated subgrade CBR and data on mat breakage and deflection at various stages of traffic. The last column in table 2 indicates the rating of the test items, based on the failure criteria described previously (paragraph 20).

35. The rated CBR for the clay subgrades, items 1-3, is based on

the numerical average of the CBR values measured at 0-, 6-, and 12-in. depths prior to traffic and at the end of the traffic period (see table 1). The sand in item 4 had an initial average CBR of 3.7, but the value increased considerably to about 43 during the traffic period, as shown in table 1. The bridging and high mat deflection, as discussed previously (paragraph 28) for this item, were caused by densification of the sand during traffic. The initial CBR value is a relative measure of the degree of density in a sand, and the lower the initial CBR value, the more settlement can be anticipated. No specific rated CBR was assigned to item 4, but comparison of mat behavior in the various items shows that an effective CBR of greater than 4.9 (rated CBR for item 2) must have been present.

36. As can be noted in table 2, item 1 was considered failed at 70 coverages and item 2 at 130 coverages. Both of these failure-coverage levels were assigned when 20 percent of the mat planks being subjected to traffic tests failed. The mat in items 3 and 4 was considered satisfactory at the end of traffic (188 coverages), although the elastic deflection of the mat in item 4 was quite high (about 1.5 in.). This high deflection did not appear to be detrimental to the mat structure, but might be objectionable from the standpoint of aircraft performance.

37. Service life. A plot of CBR versus coverages for the uniform coverage traffic with a 27,000-lb single-wheel load and 400-psi tire pressure is shown in plate 9. The points plotted are the rated CBR values listed in table 2 for the clay subgrade and the corresponding number of coverages at the end of traffic. The CBR at the beginning and end of traffic is indicated for the sand subgrade. The failure points are indicated by closed symbols, and a satisfactory condition is indicated by open symbols. From previous tests on landing mats, it has been established that CBR-coverage relations for mats result in essentially a straight-line relation when plotted to a logarithmic scale. Therefore, the straight line projected through the two failure points on plate 9 indicates the CBR required to support the test load for various coverage levels. The indicated CBR required to support 188 coverages of traffic is about 6.2.

Test lane 2, single-line traffic

38. Analysis. A summary of the test results from the single-line traffic (test lane 2) is shown in table 3. This table shows the same type of data as previously discussed for the uniform-coverage traffic tests. From this table it can be noted that the mat in item 1 was considered failed at 1000 passes of the load wheel and that items 2 and 4 were failed at the end of 1600 passes. Only test item 3 was considered satisfactory at the end of traffic.

39. Service life. A plot of CBR versus passes of the 27,000-lb single-wheel load applied in a single track is shown in plate 10. From these data the indicated subgrade CBR required under the mat to support 1600 passes of the test load wheel is 5.1. In plate 10, it can be noted that mat failure did occur over the sand subgrade where the CBR value was 36 at the end of the traffic period. This failure was caused not by inadequate subgrade strength, but by settlement of the sand in the traffic path, which caused the mat to deform over the depression in the subgrade. This resulted in structural core failures in the mat planks.

Discussion of test results

40. Comparison of the data in plates 9 and 10 shows that slightly higher subgrade strengths are required under the mat to support 188 coverages of traffic uniformly distributed over a 10-ft width than is required to support 1600 passes of the load wheel in a single track. However, it should be recognized that most of the failures from the uniform-coverage traffic were end-joint weld failures. Since the single-line traffic was applied 2 ft away from any end joints, there could be no end-joint failures in these tests. The failures which did develop were either core failures or longitudinal weld failures. Therefore, the service life of the mat under single-line traffic applied at any other location on the mat surface may be considerably different from that indicated by these tests.

41. The behavior of the mat in these tests was not affected to any material extent by the two-piece welded configuration of the mat. As pointed out above, distributed traffic failures occurred most frequently in the end joints, while in the single-line traffic tests, core failures occurred within the extrusions as much as they did in the longitudinal welds.

PART IV: CONCLUSIONS

42. Based on the data presented in this report, the following conclusions are believed to be warranted:

a. The Harvey aluminum two-piece AM2 will sustain 1600 cycles (188 coverages) of aircraft operations with a 27,000-lb single-wheel load and 400-psi tire-inflation pressure when placed on a subgrade having a CBR of 6.2 or greater throughout the period of traffic.

b. The Harvey aluminum two-piece AM2 will sustain 1600 passes of a 27,000-lb single-wheel load with a tire-inflation pressure of 400-psi in a single path (located 2 ft or more away from the mat end joints) when placed on a subgrade having a CBR of 5.1 or greater throughout the period of traffic.

c. General behavior of the mat in these tests was not materially affected by the two-piece nature of the mat panels.

Table 1

Summary of CBR, Density, and Water Content Data

Test Lane	Test Item	Subgrade Material	Prior to Traffic: Pit No.	Depth in.	CBR	Water Content %	Dry Density lb/cu ft	Avg CBR	After Traffic: Pit No.	Depth in.	CBR	Water Content %	Dry Density lb/cu ft	Avg CBR
1	1	Heavy	1 and 2	0	2.4	28.3	90.9		9	0	3.2	27.4	93.3	
		Clay	Avg	6	2.4	30.3	92.3			6	3.2	26.8	93.8	
				12	4.0	28.1	93.9	2.9		12	4.3	26.9	94.0	3.6
	2	Heavy	3 and 4	0	5.3	23.3	99.3		10	0	6.0	24.7	99.2	
		Clay	Avg	6	4.3	25.7	93.9			6	3.8	26.0	94.2	
				12	4.7	28.2	94.5	4.8		12	5.0	24.7	95.8	4.9
	3	Heavy	5 and 6	0	10.0	23.0	98.9		11	0	11.0	22.1	101.3	
		Clay		6	9.0	23.1	100.6			6	8.0	23.5	100.4	
				12	10.0	22.1	98.4	10.0		12	13.0	22.3	101.6	11.0
	4	Sand	7 and 8	0	2.9	10.1	101.9		12	0	35.0	6.7	112.7	
				6	4.5	10.7	103.8			6	46.0	7.8	114.8	
				12	4.0	10.1	101.7	3.7		12	48.0	8.0	111.8	43.0
2	1	Heavy	1 and 2	0	2.4	28.3	90.9		13	0	2.3	30.1	90.1	
		Clay		6	2.4	30.3	92.3			6	3.3	29.3	94.3	
				12	4.0	28.1	93.9	2.9		12	5.1	27.4	96.1	3.6
	2	Heavy	3 and 4	0	5.3	23.3	99.3		14	0	3.8	28.3	99.0	
		Clay		6	4.3	25.7	93.9			6	5.3	25.7	93.9	
				12	4.7	28.2	94.5	4.8		12	7.0	25.4	99.8	5.4
	3	Heavy	5 and 6	0	10.0	23.0	98.9		15	0	10.0	22.8	102.3	
		Clay		6	9.0	23.1	100.6			6	11.0	22.8	101.8	
				12	10.0	22.1	98.4	10.0		12	9.0	23.2	99.3	10.0
	4	Sand	7 and 8	0	2.9	10.1	101.9		16	0	36.0	6.8	109.5	
				6	4.5	10.7	103.8			6	40.0	6.0	109.4	
				12	4.0	10.1	101.7	3.7		12	33.0	7.2	107.6	36.0

Table 2

Summary of Test Results for Uniform-Coverage Traffic

27,000-lb Single-Wheel Load, 400-psi Tire Pressure

Test Item	Subgrade Material	Rated Subgrade CBR*	No. Planks Subjected to Traffic	Traffic Coverages	Mat Breakage: End-Joint Weld Cracks	Mat Breakage: End-Joint Weld Failures	Mat Breakage: Longitudinal Weld Breaks	Mat Breakage: Longitudinal Weld Failures	Mat Breakage: Indicated Core Damage	Mat Breakage: Total No. Planks Failed	Maximum Mat Deflection in.	Rating of Item
1	Heavy Clay	3.3	30	0	0	0	0	0	0	0	1.0	
				20	9	1	0	0	0	1	0.9	
				40	10	4	1	0	0	4	1.2	
				70	10	5	3	1	0	6	1.0	Failed
2	Heavy Clay	4.9	30	0	0	0	0	0	0	0	0.9	
				20	0	0	0	0	0	0	0.8	
				40	3	0	0	0	0	0	0.7	
				70	8	1	2	0	0	1	--	
				130	10	6	4	0	0	6	0.7	Failed
3	Heavy Clay	10.2	30	0	0	0	0	0	0	0	0.6	
				20	1	0	0	0	0	0	0.5	
				40	1	0	0	0	0	0	0.5	
				70	1	0	0	0	0	0	--	
				130	5	1	0	0	1	1	0.6	
				188	5	1	0	0	1	1	0.6	Satisfactory
4	Sand	3.7-43.0	23	0	0	0	0	0	0	0	0.5	
				20	0	0	0	0	0	0	0.8	
				40	0	0	0	0	0	0	1.3	
				70	0	0	0	0	0	0	--	
				130	0	0	0	0	0	0	1.2	
				188	0	0	0	0	0	0	1.5	Satisfactory

* Rated subgrade CBR values represent the average values for 0-, 6-, and 12-in. depths before and after traffic

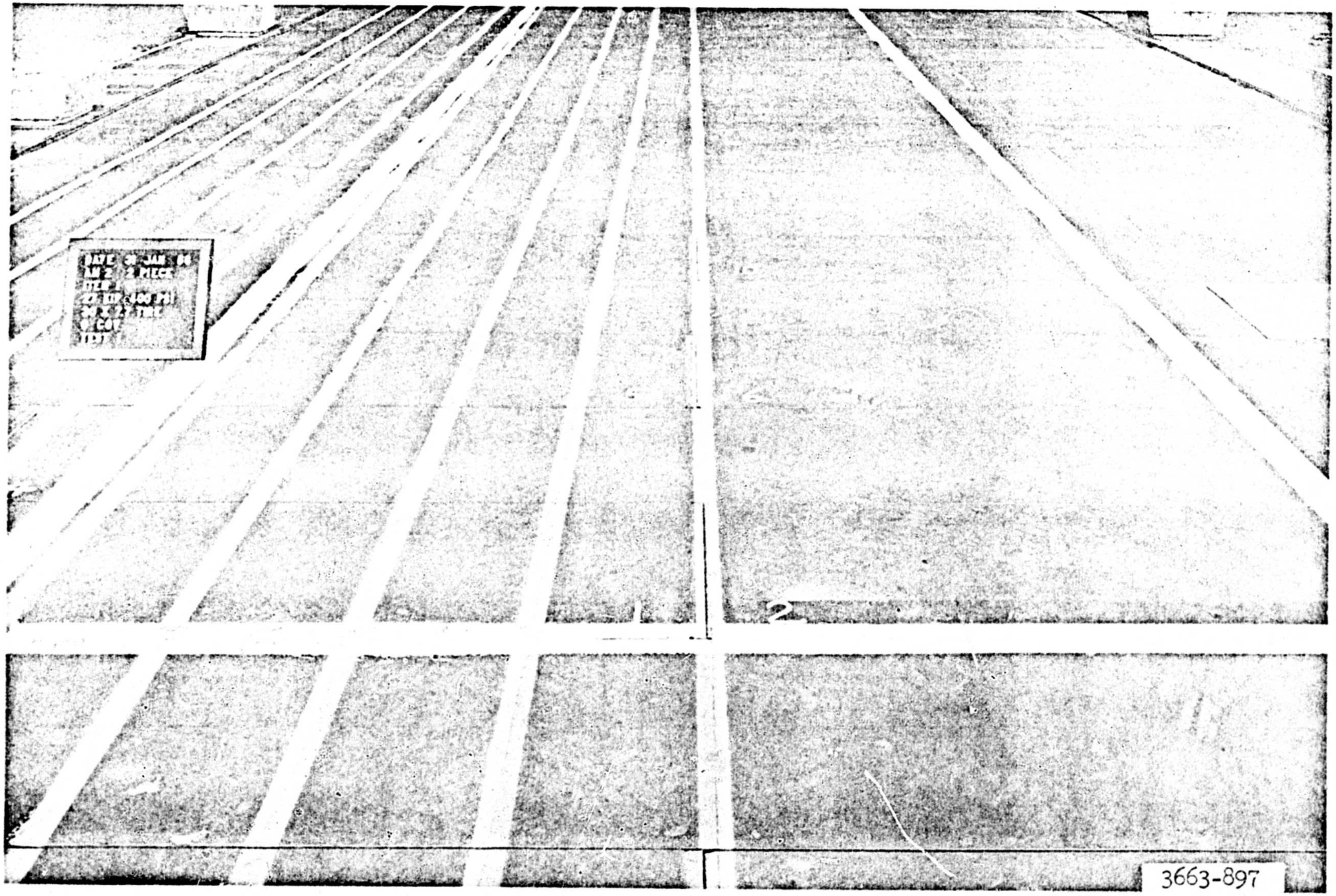
Table 3

Summary of Test Results for Single-Track Traffic

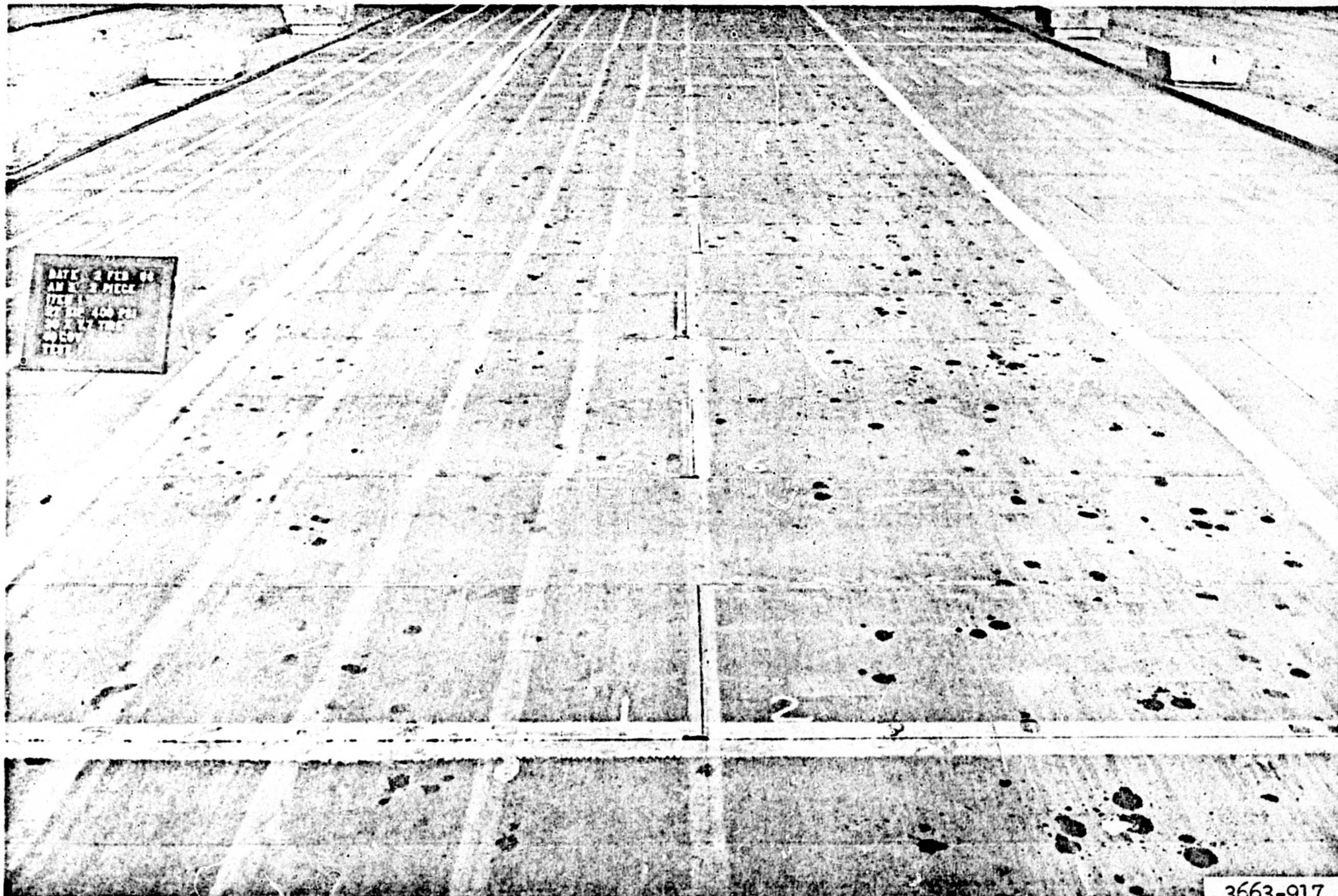
27,000-lb Single-Wheel Load, 400-psi Tire Pressure

Test Item	Subgrade Material	Rated Subgrade CBR*	No. Planks Subjected to Traffic	Traffic Passes	Mat Breakage: Longitudinal Weld Breaks	Mat Breakage: Longitudinal Weld Failures	Mat Breakage: Indicated Core Damage	Mat Breakage: Core Failures	Mat Breakage: Total No. Planks Failed	Maximum Mat Deflection in.	Rating of Item
1	Heavy Clay	3.3	20	0	0	0	0	0	0	1.0	
				600	3	0	1	0	0	--	
				1000	4	0	9	7	7	1.8	Failed
2	Heavy Clay	5.1	20	0	0	0	0	0	0	0.6	
				600	1	0	0	0	0	--	
				1000	2	0	2	0	0	0.7	
				1600	12	0	7	4	4	0.9	Failed
3	Heavy Clay	10.0	20	0	0	0	0	0	0	0.5	
				600	0	0	0	0	0	--	
				1000	0	0	0	0	0	0.6	
				1600	1	0	0	0	0	0.6	Satisfactory
4	Sand	3.7-36.0	15	0	0	0	0	0	0	0.7	
				600	0	0	0	0	0	--	
				1000	2	0	1	0	0	1.1	
				1600	7	0	7	4	4	1.1	Failed

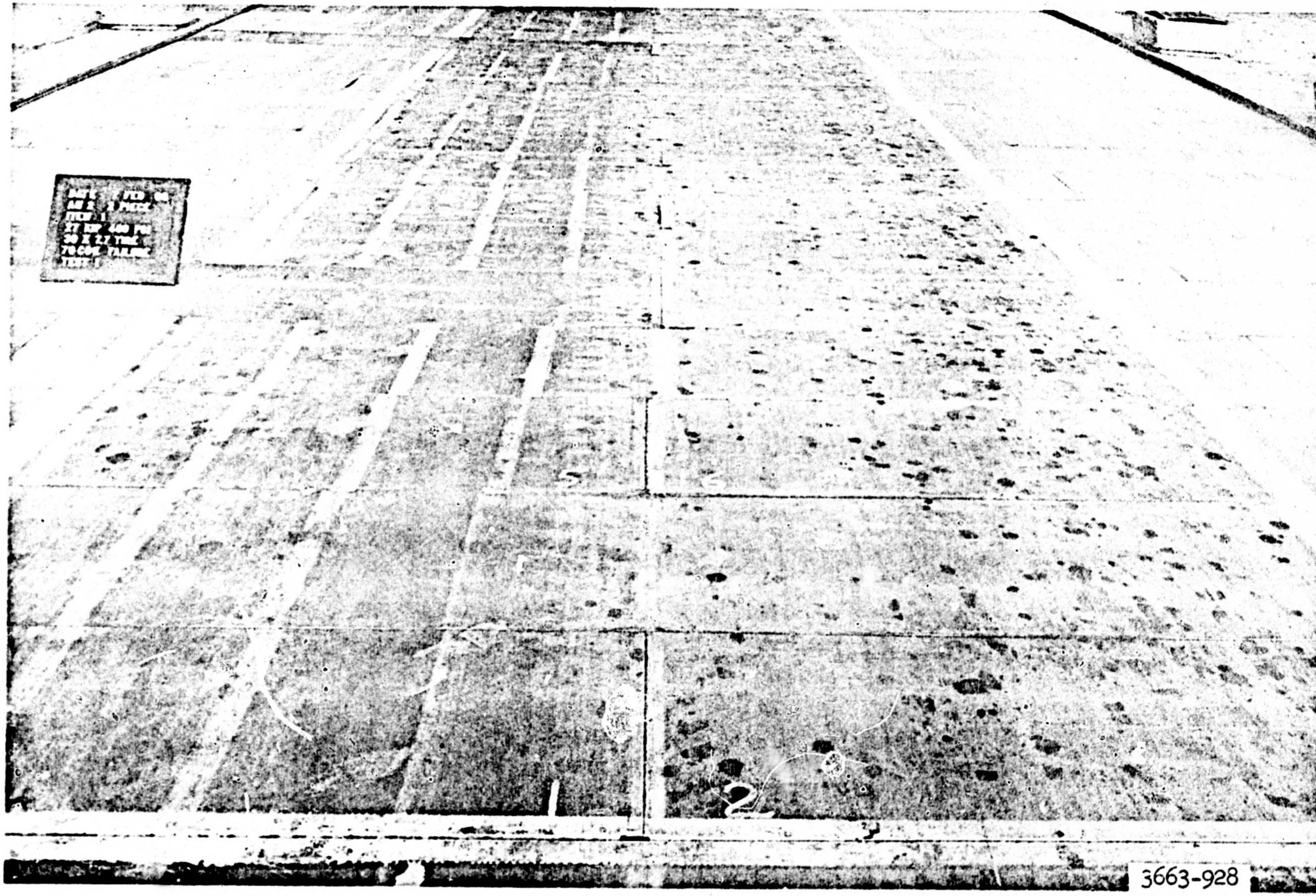
* Rated subgrade CBR values represent the average values for 0-, 6-, and 12-in. depths before and after traffic.



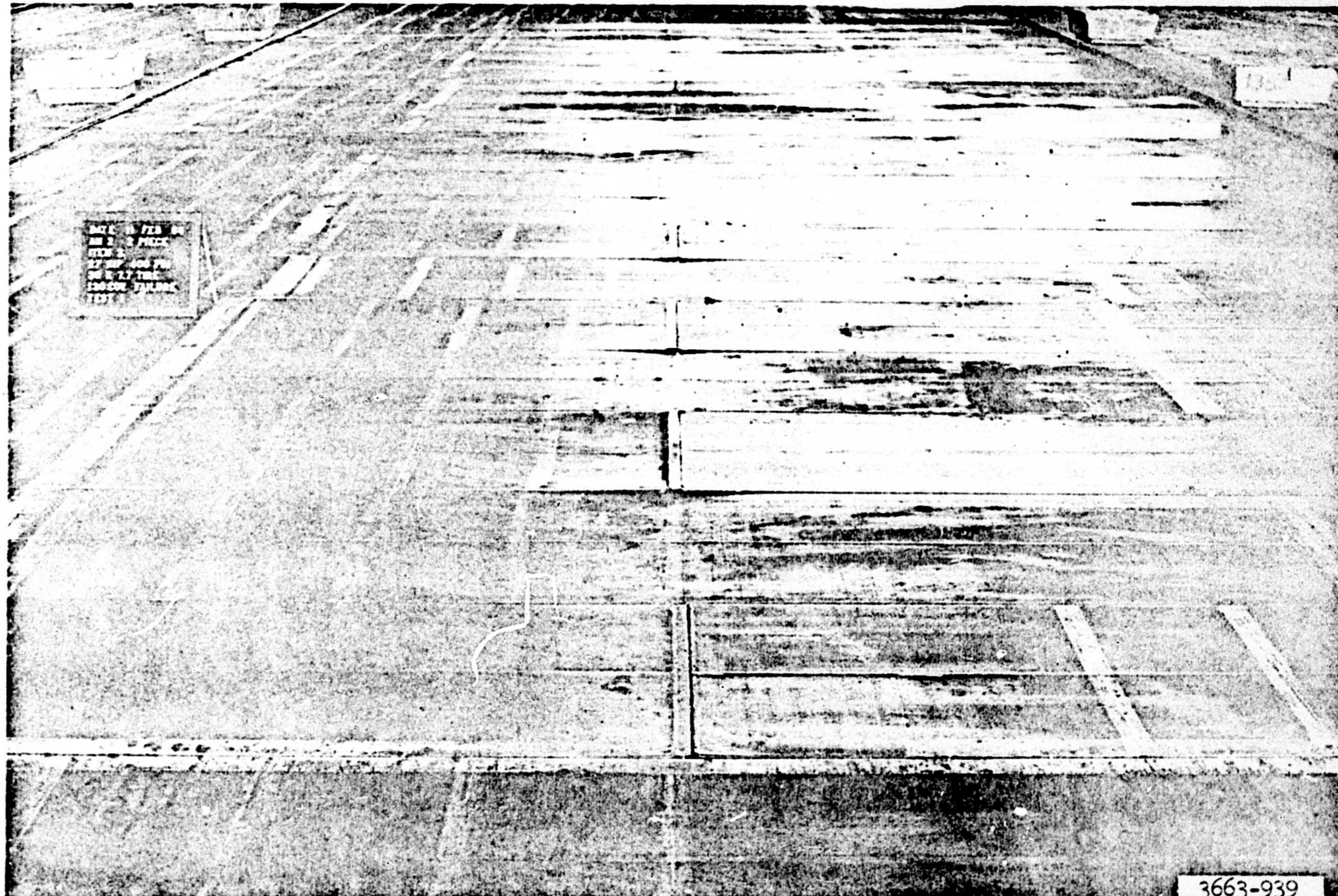
Photograph 1. Test section prior to traffic



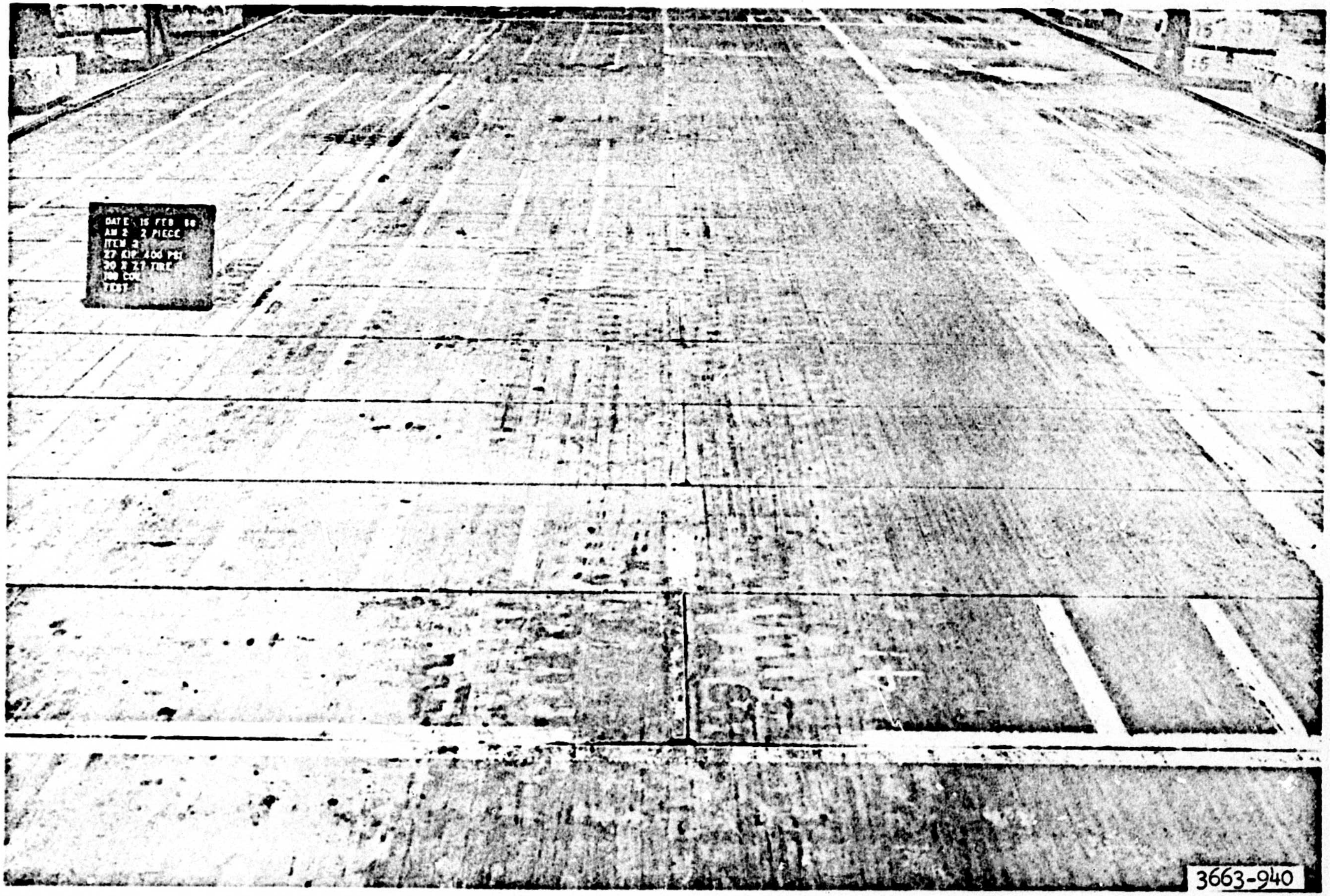
Photograph 2. Lane 1, item 1, after 40 coverages



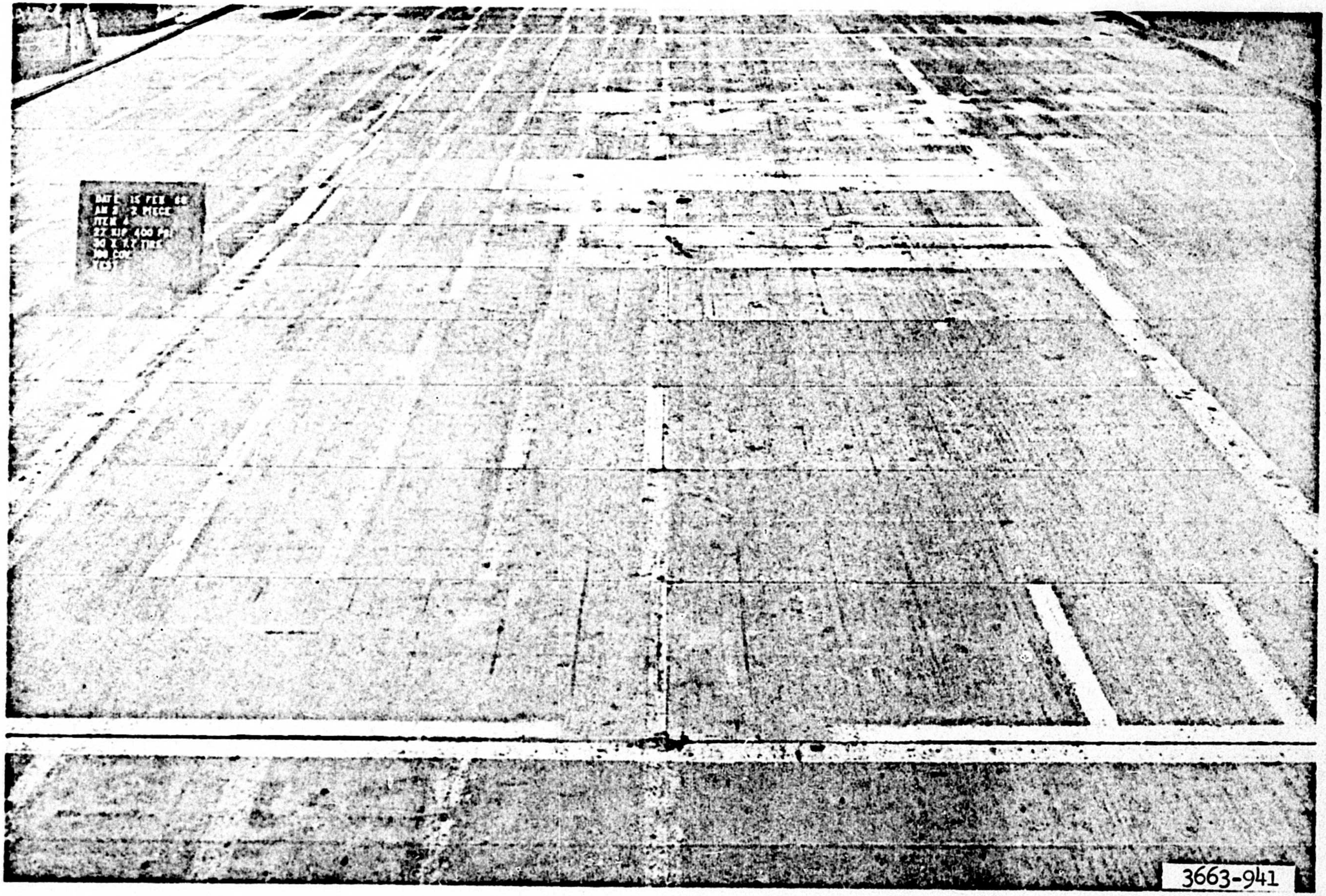
Photograph 3. Lane 1, item 1, at failure after 70 coverages



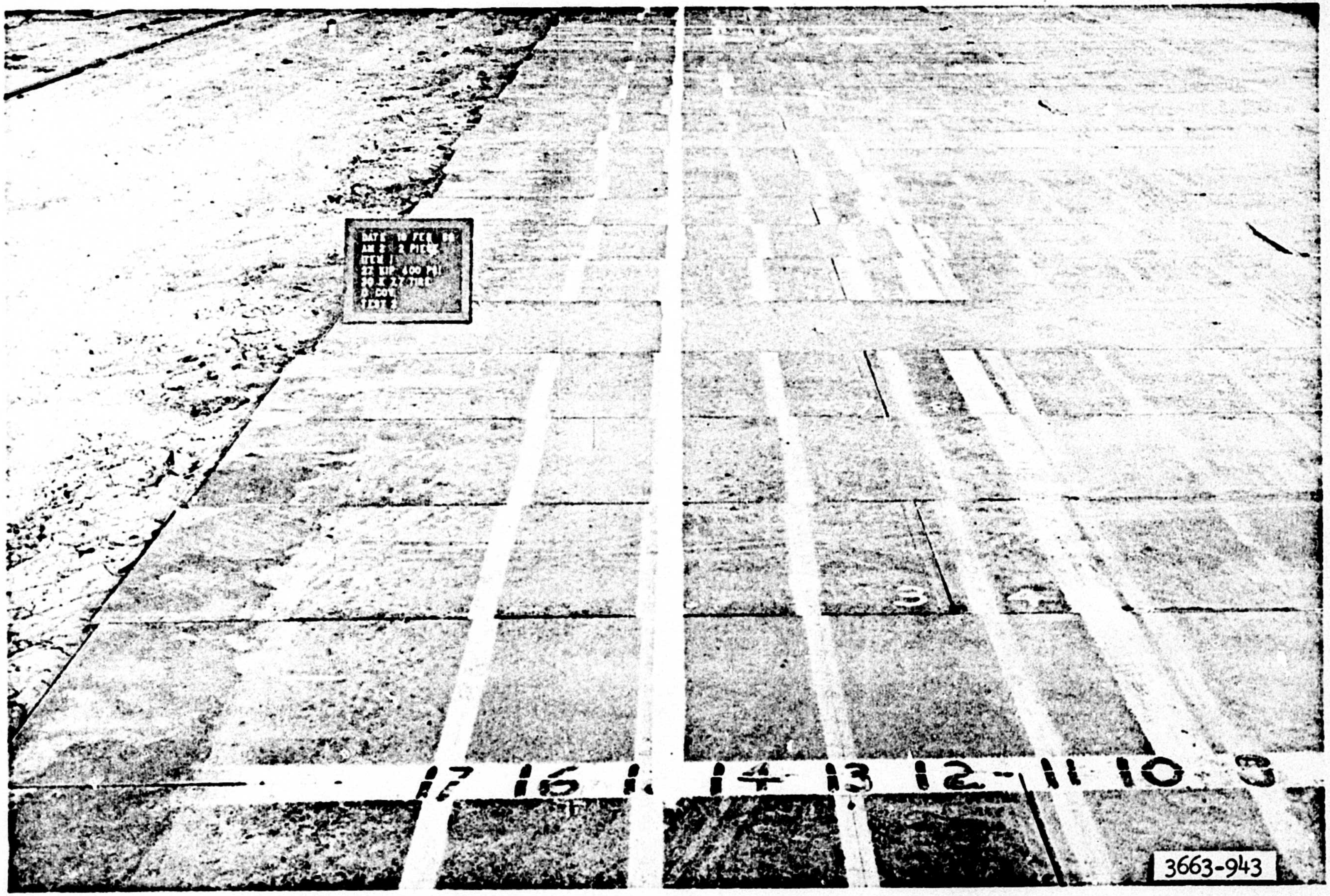
Photograph 4. Lane 1, item 2, at failure after 130 coverages



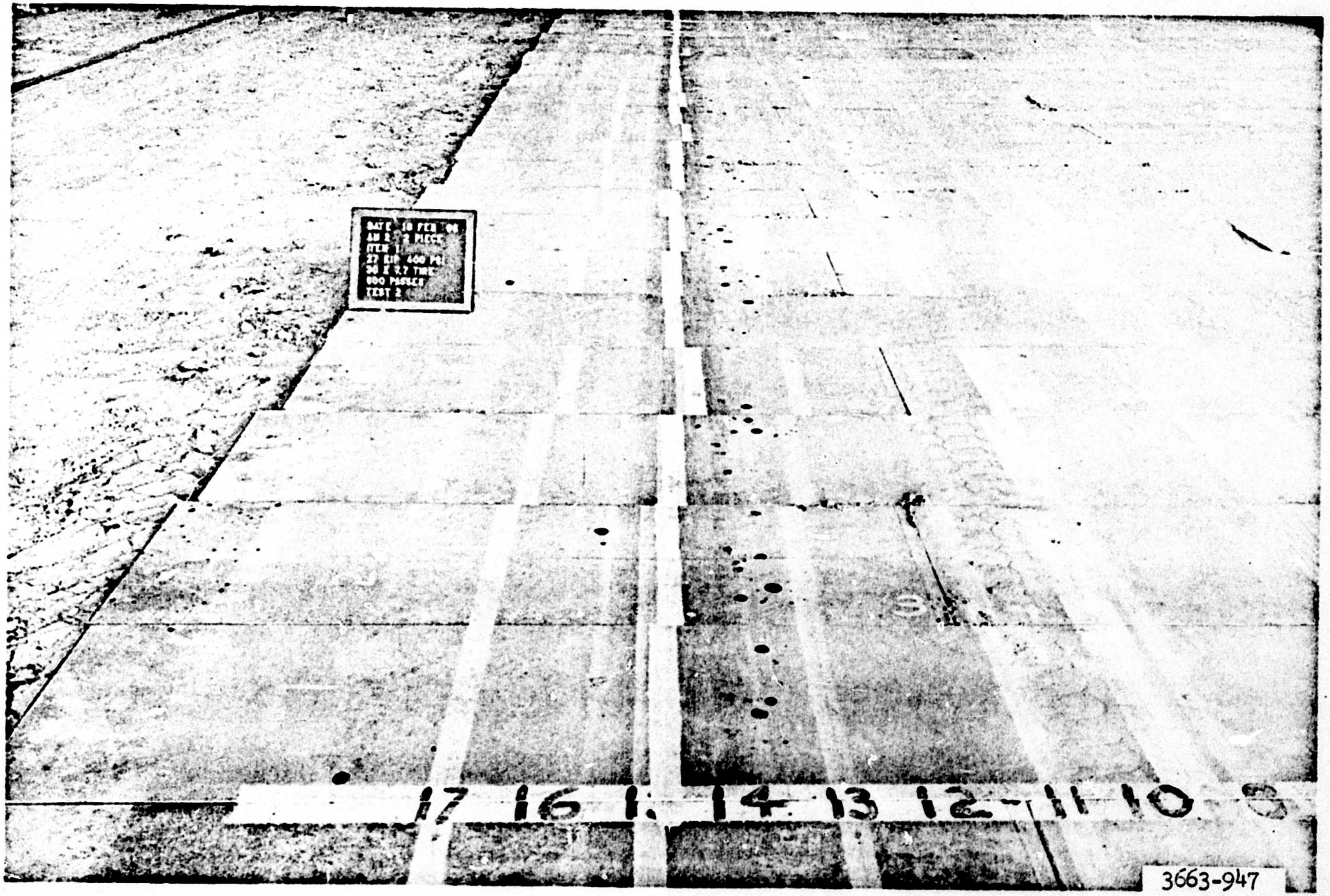
Photograph 5. Lane 1, item 3, after 188 coverages



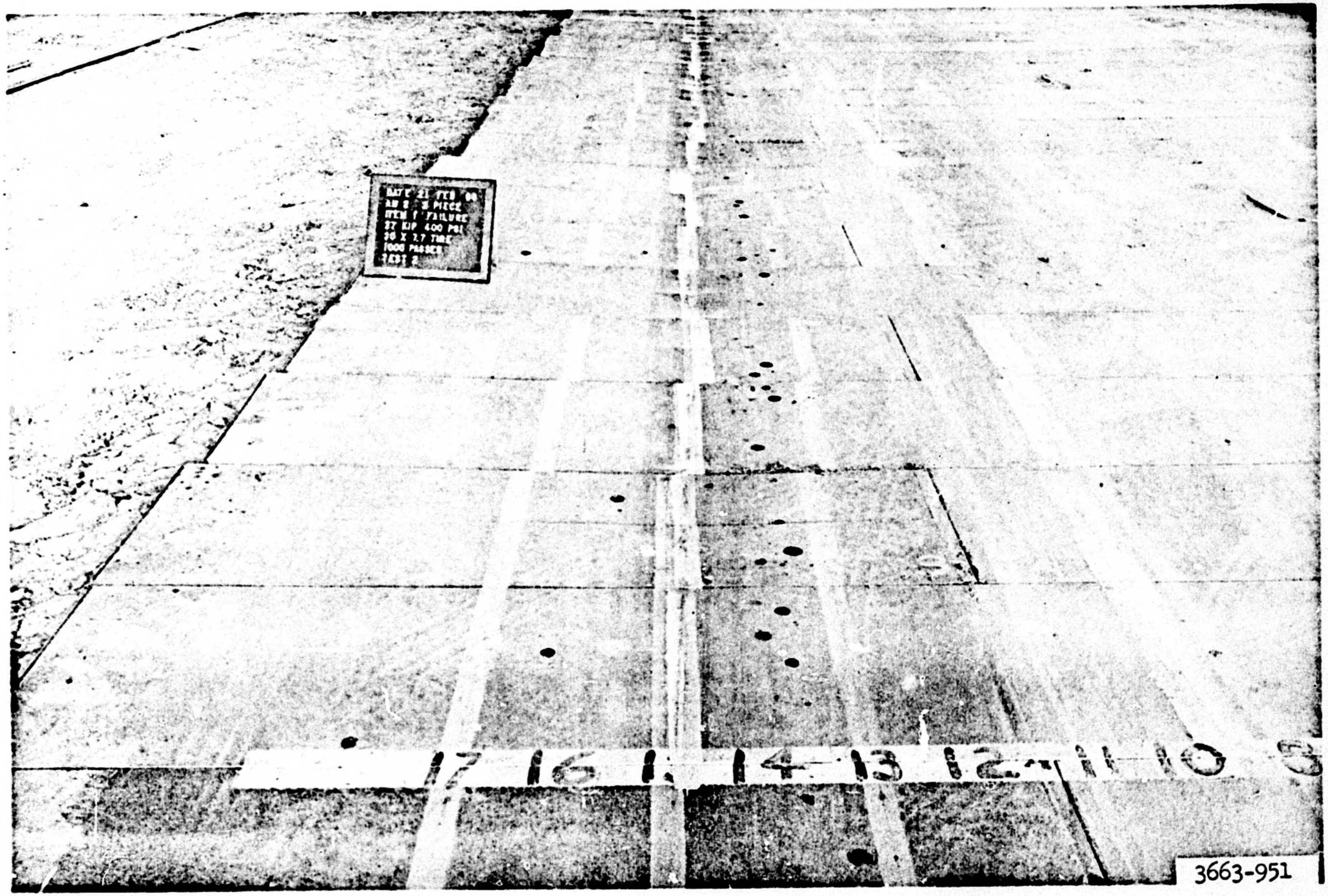
Photograph 6. Lane 1, item 4, after 188 coverages



Photograph 7. Test lane 2, prior to traffic

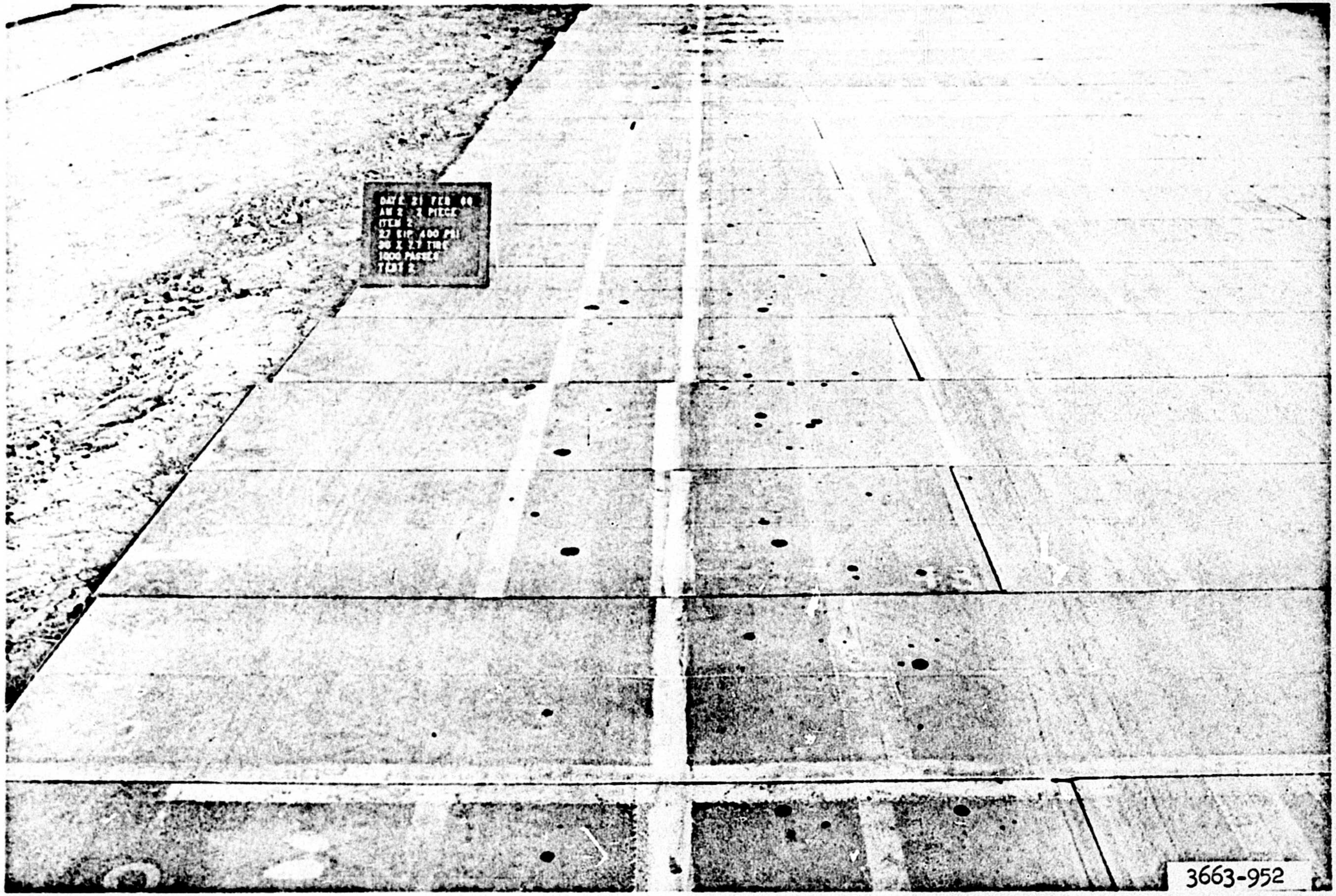


Photograph 8. Lane 2, item 1, after 600 passes

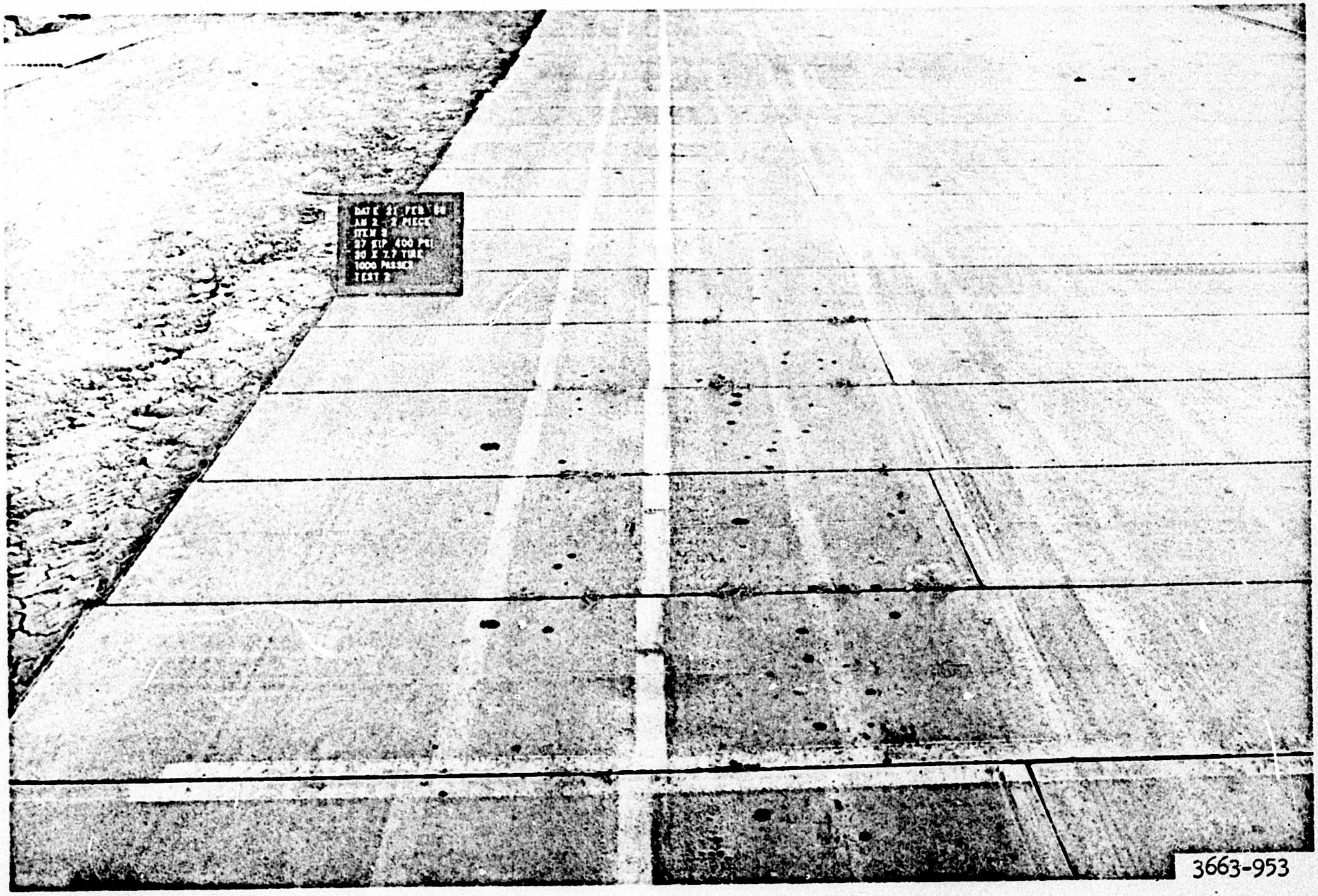


Photograph 9. Lane 2, item 1, at failure after 100 passes

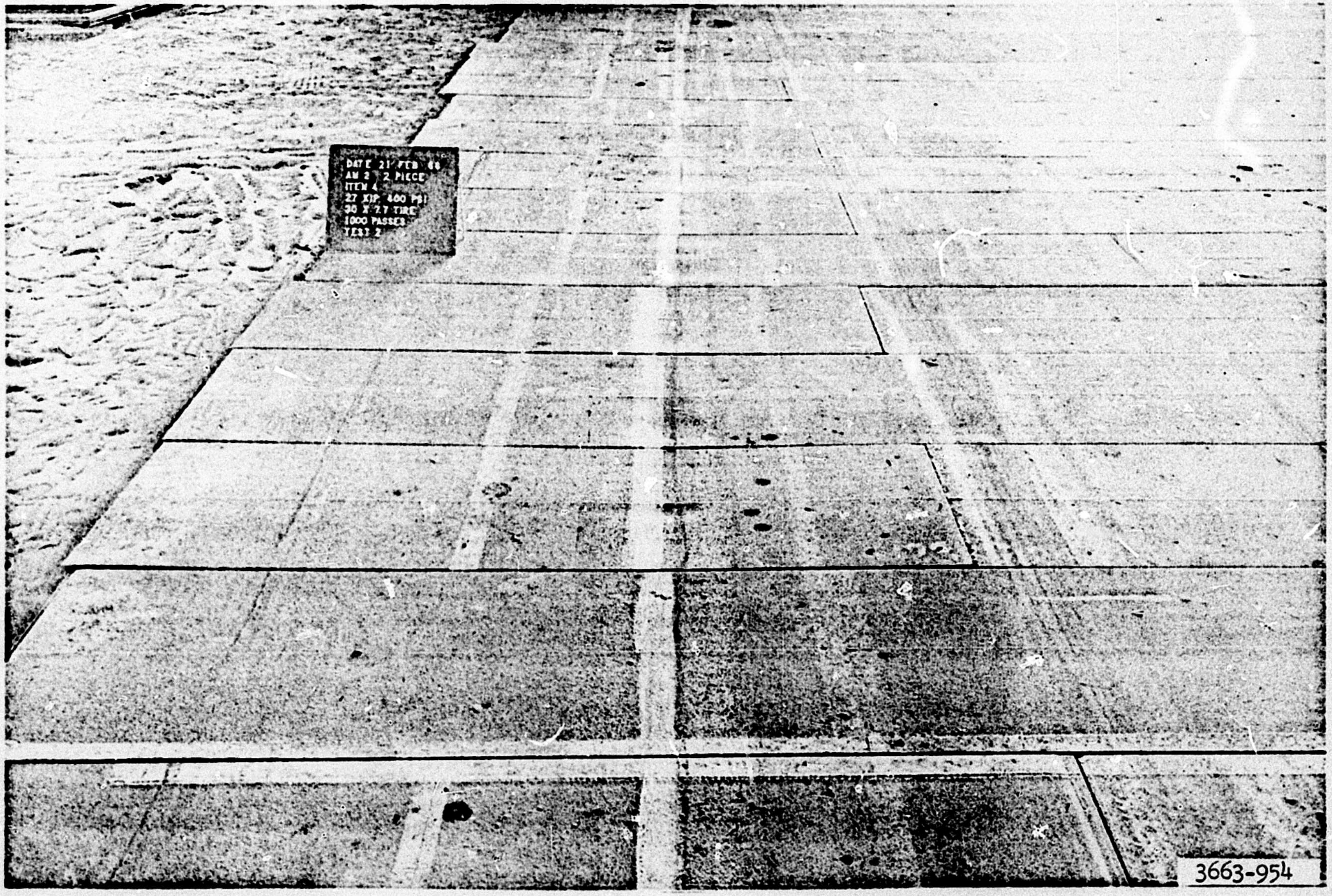
Photograph 10. Lane 2, item 1, after 1000 passes. Note bending of mat causing edges of planks to project upwards



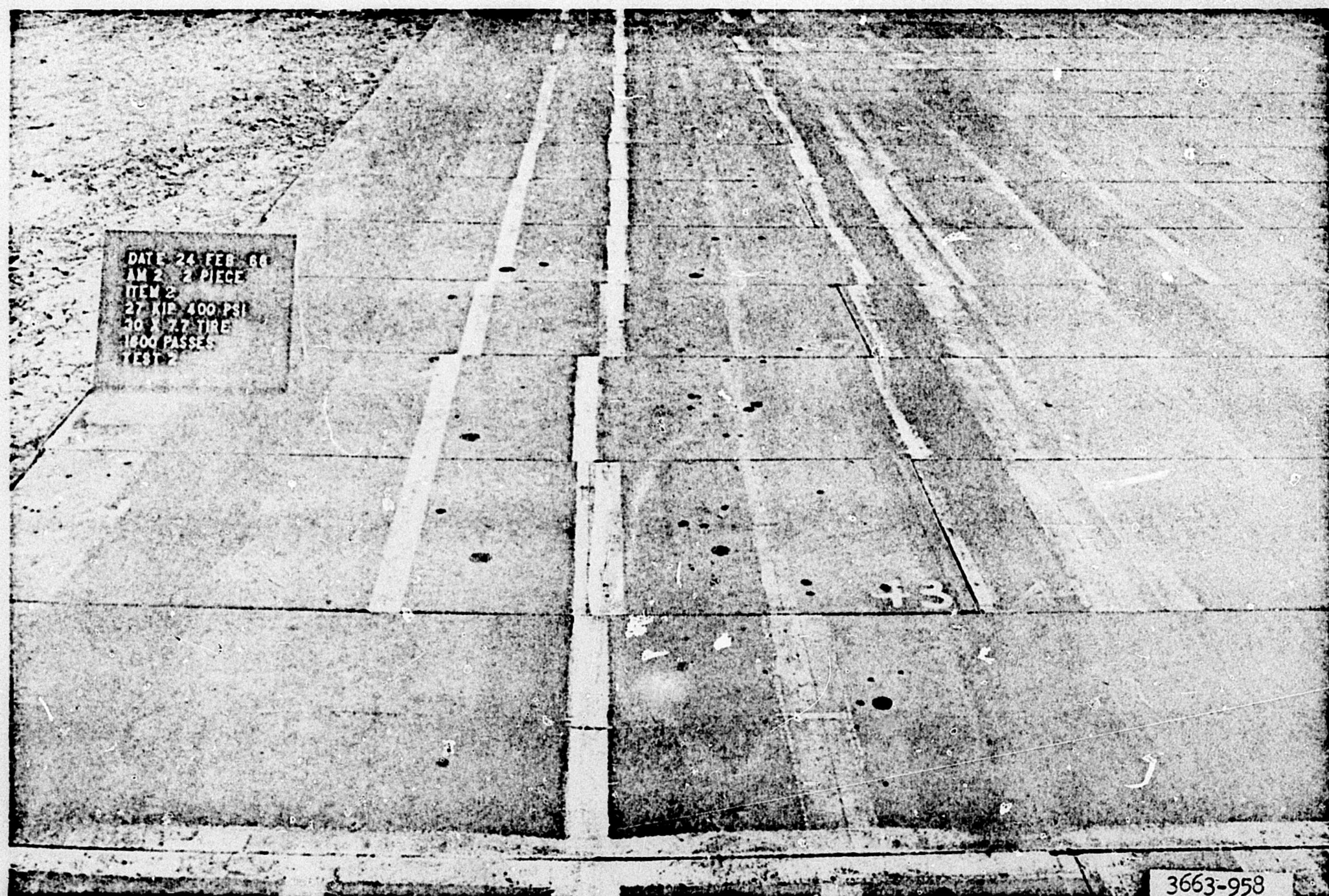
Photograph 11. Lane 2, item 2, after 1000 passes



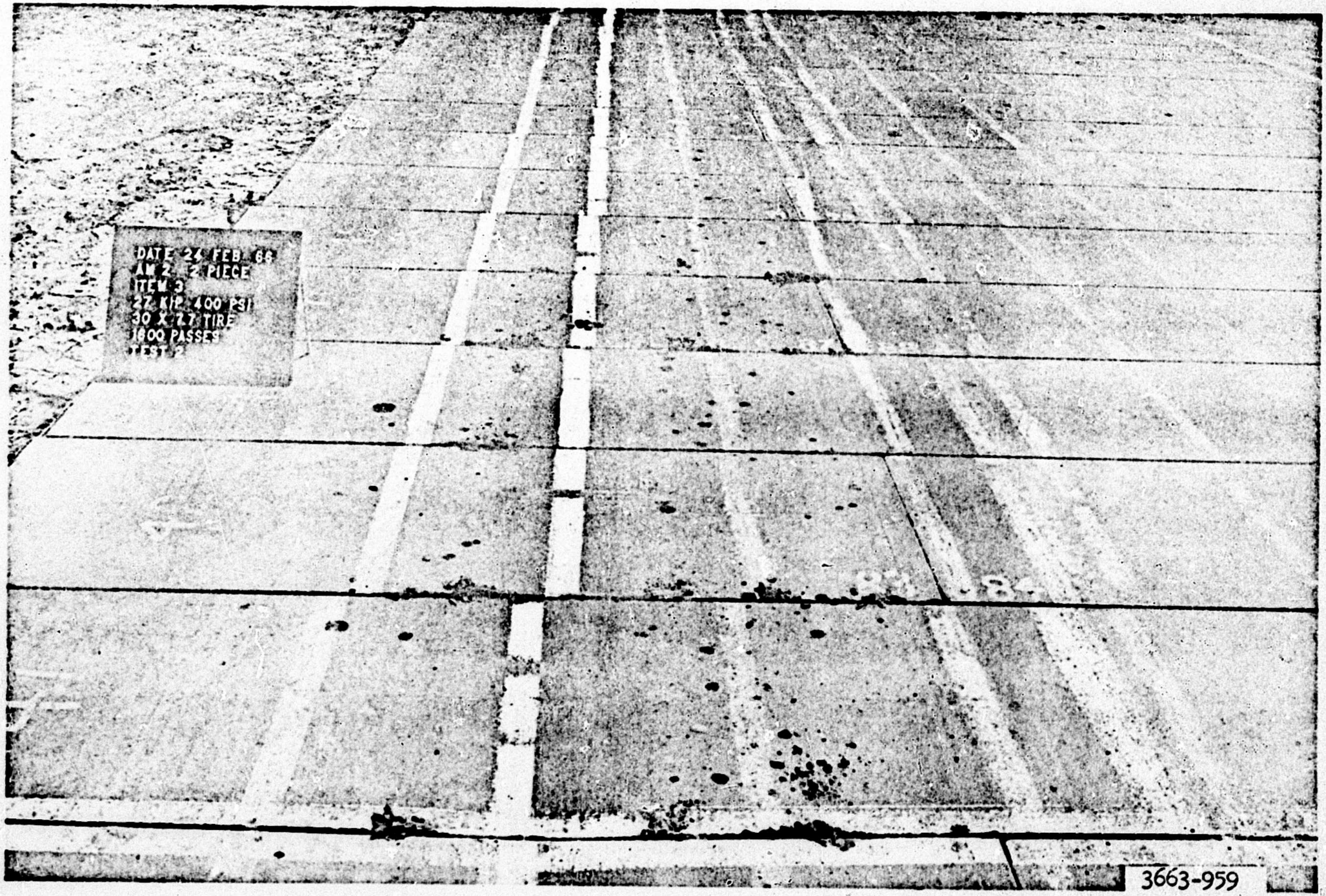
Photograph 12. Lane 2, item 3, after 1000 passes



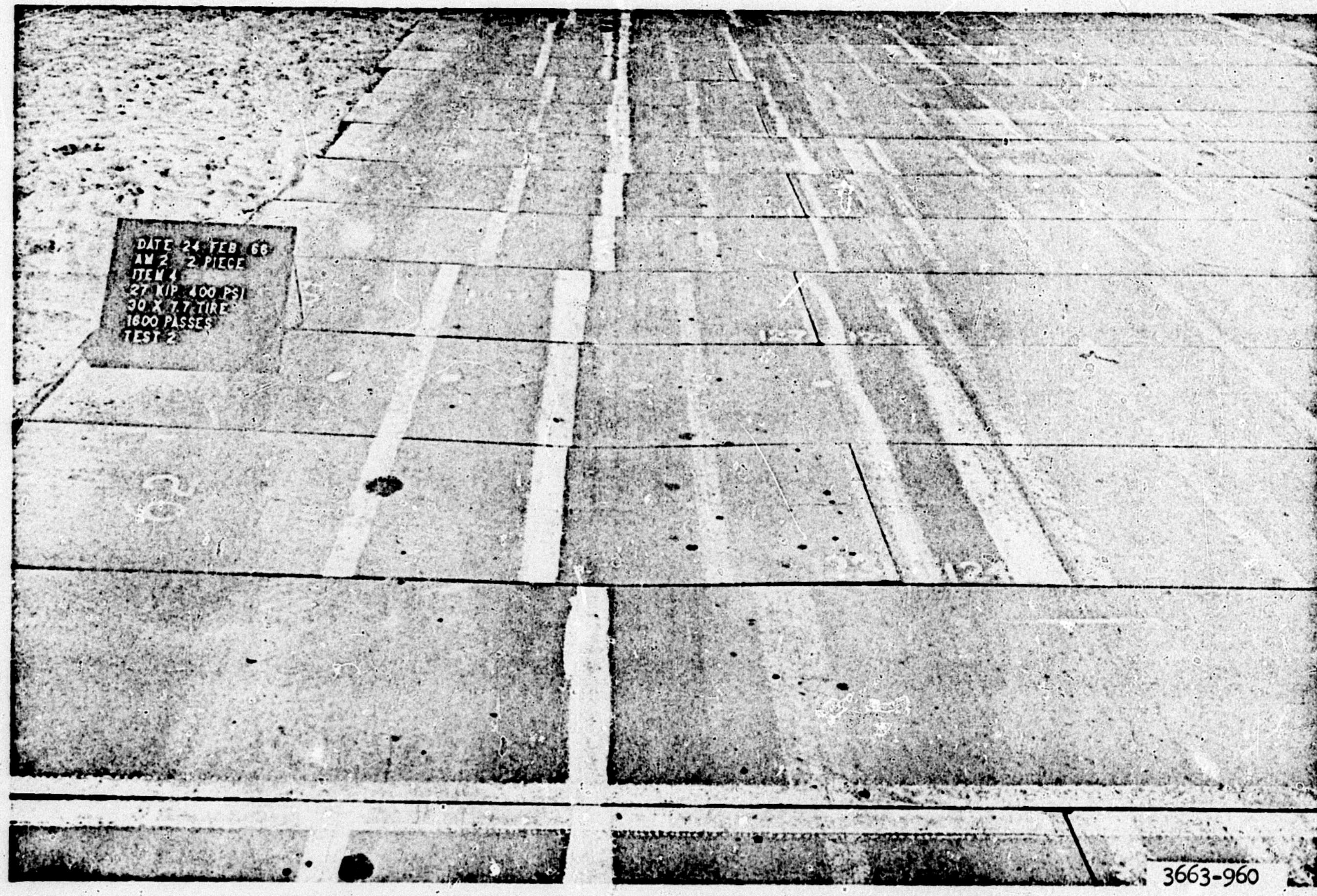
Photograph 13. Lane 2, item 4, after 1000 passes



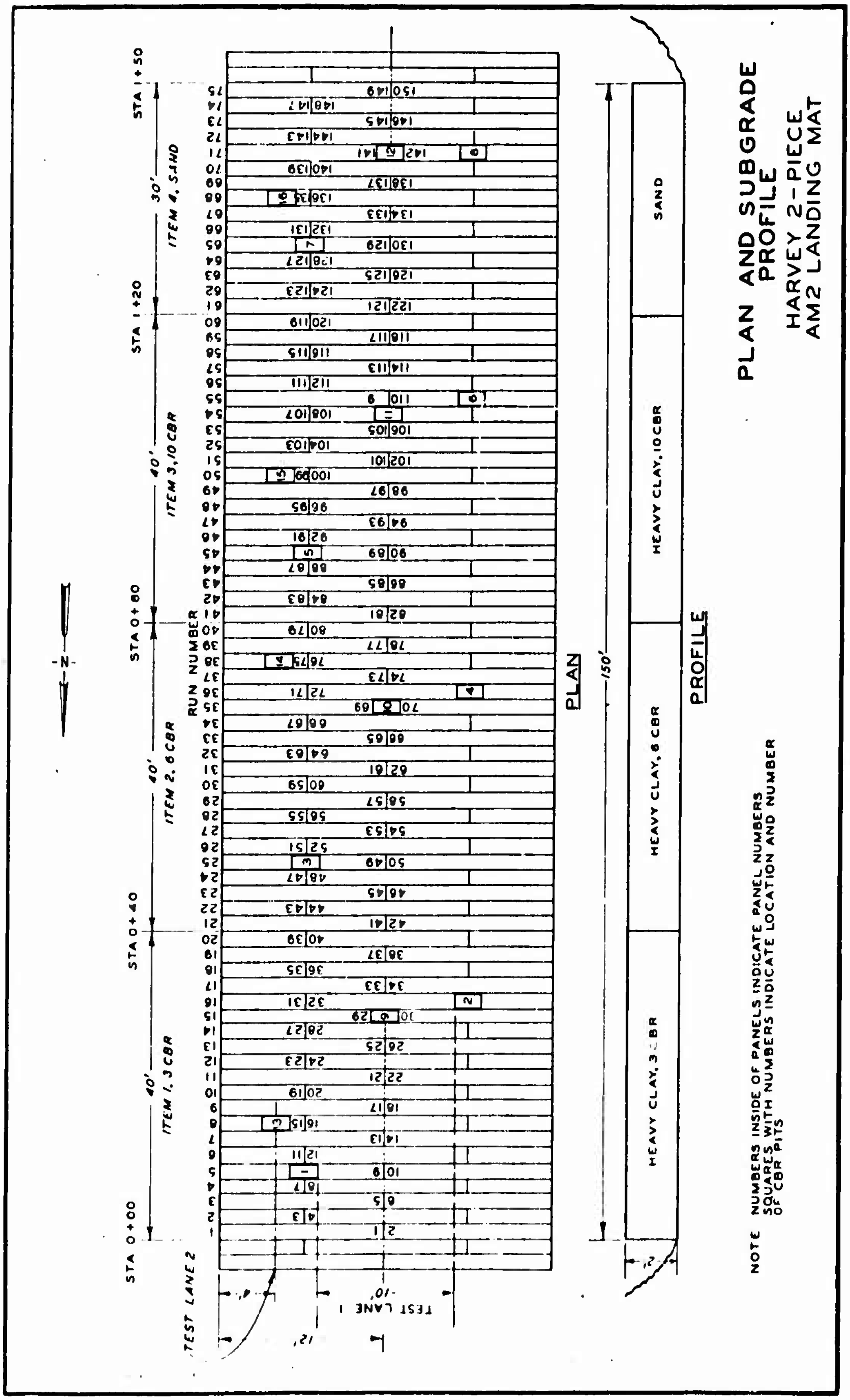
Photograph 14. Lane 2, item 2, at failure after 1600 passes



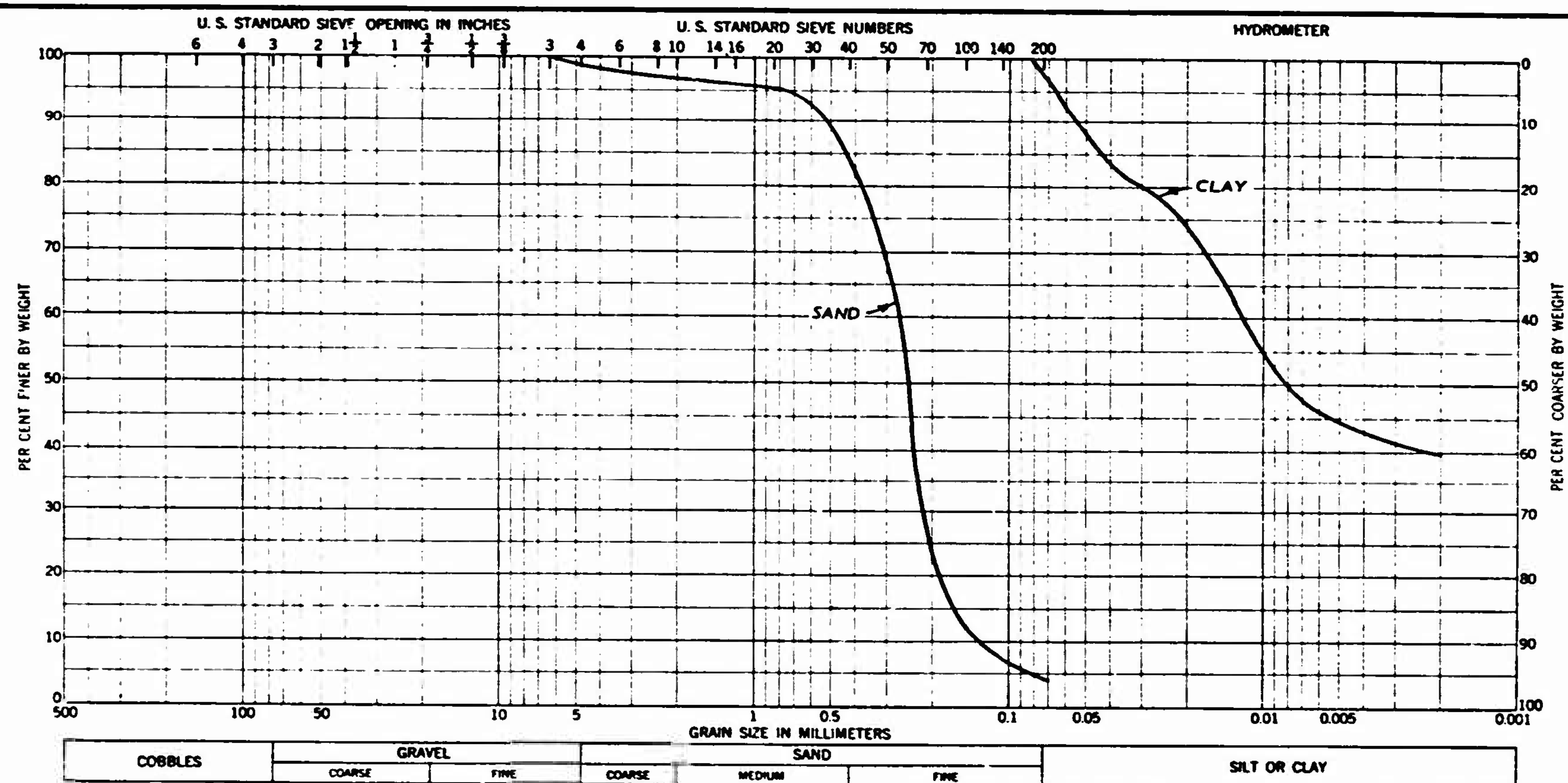
Photograph 15. Lane 2, item 3, after 1600 passes



Photograph 16. Lane 2, item 4, at failure after 1600 passes



PLAN AND SUBGRADE PROFILE
HARVEY 2-PIECE
AM2 LANDING MAT



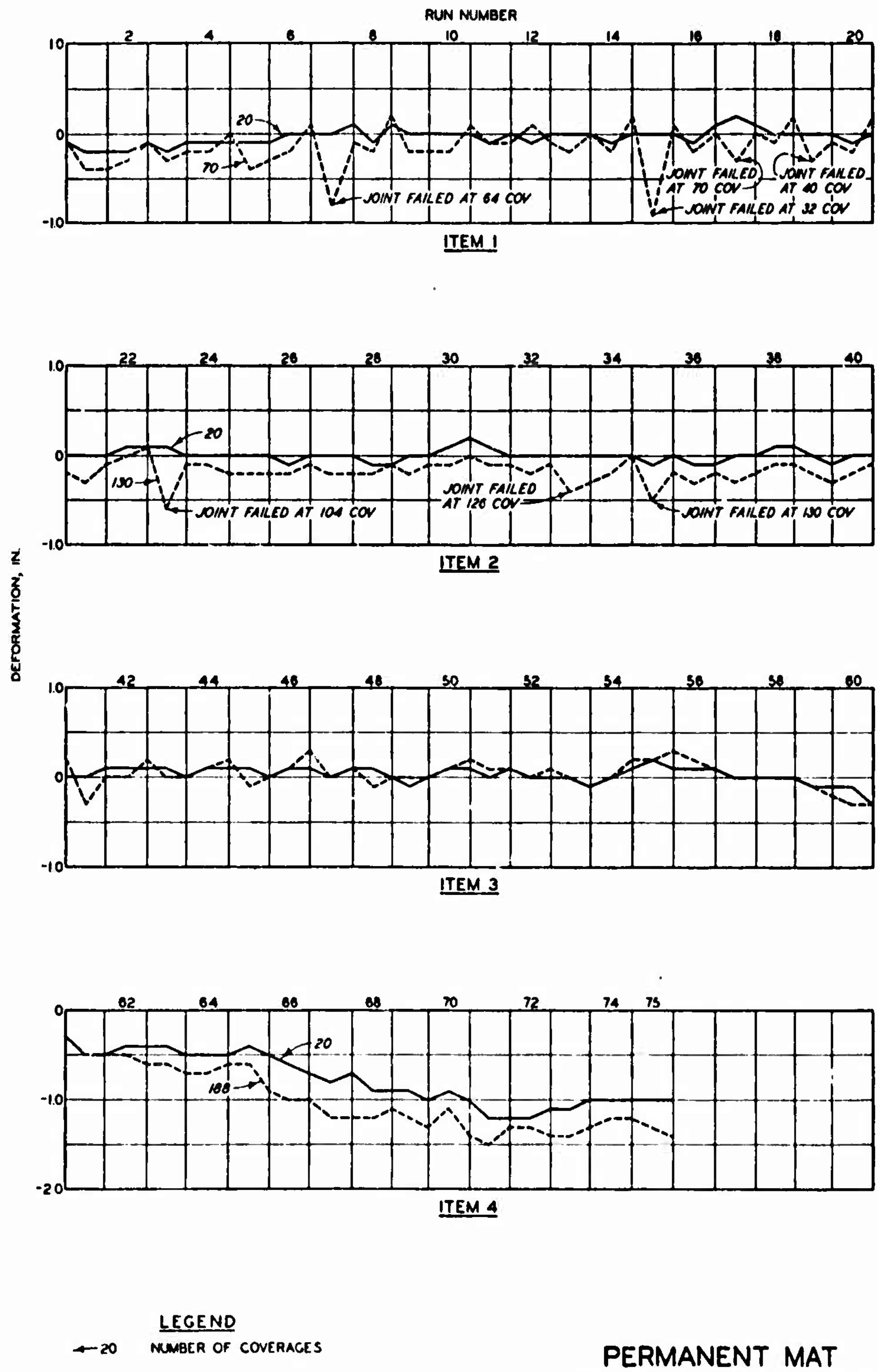
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
		HEAVY CLAY (BUCKSHOT), CH		58	27	31

GRADATION CURVES

CLASSIFICATION DATA

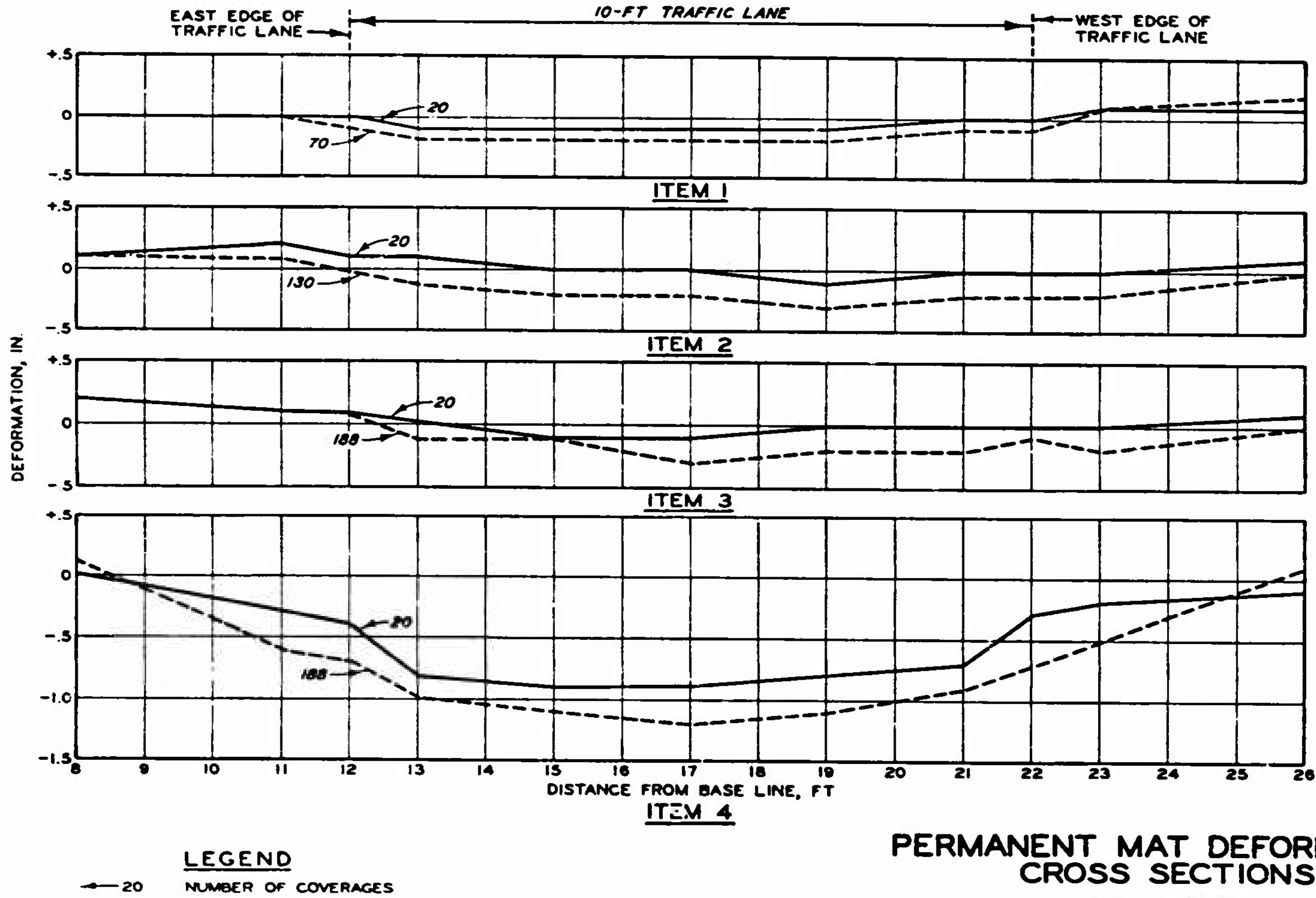
SUBGRADE SOILS

PLATE 2



PERMANENT MAT DEFORMATION PROFILE

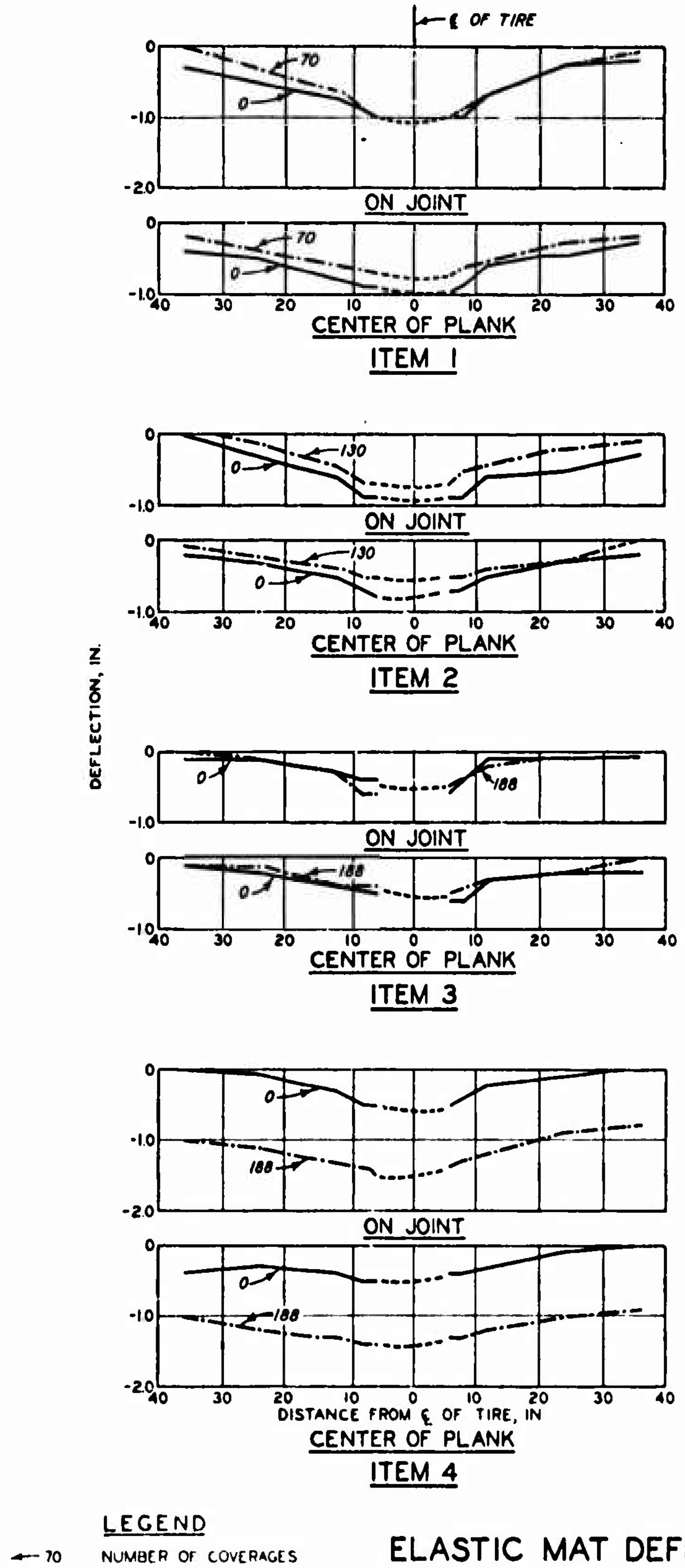
TEST LANE I
UNIFORM-COVERAGE TRAFFIC



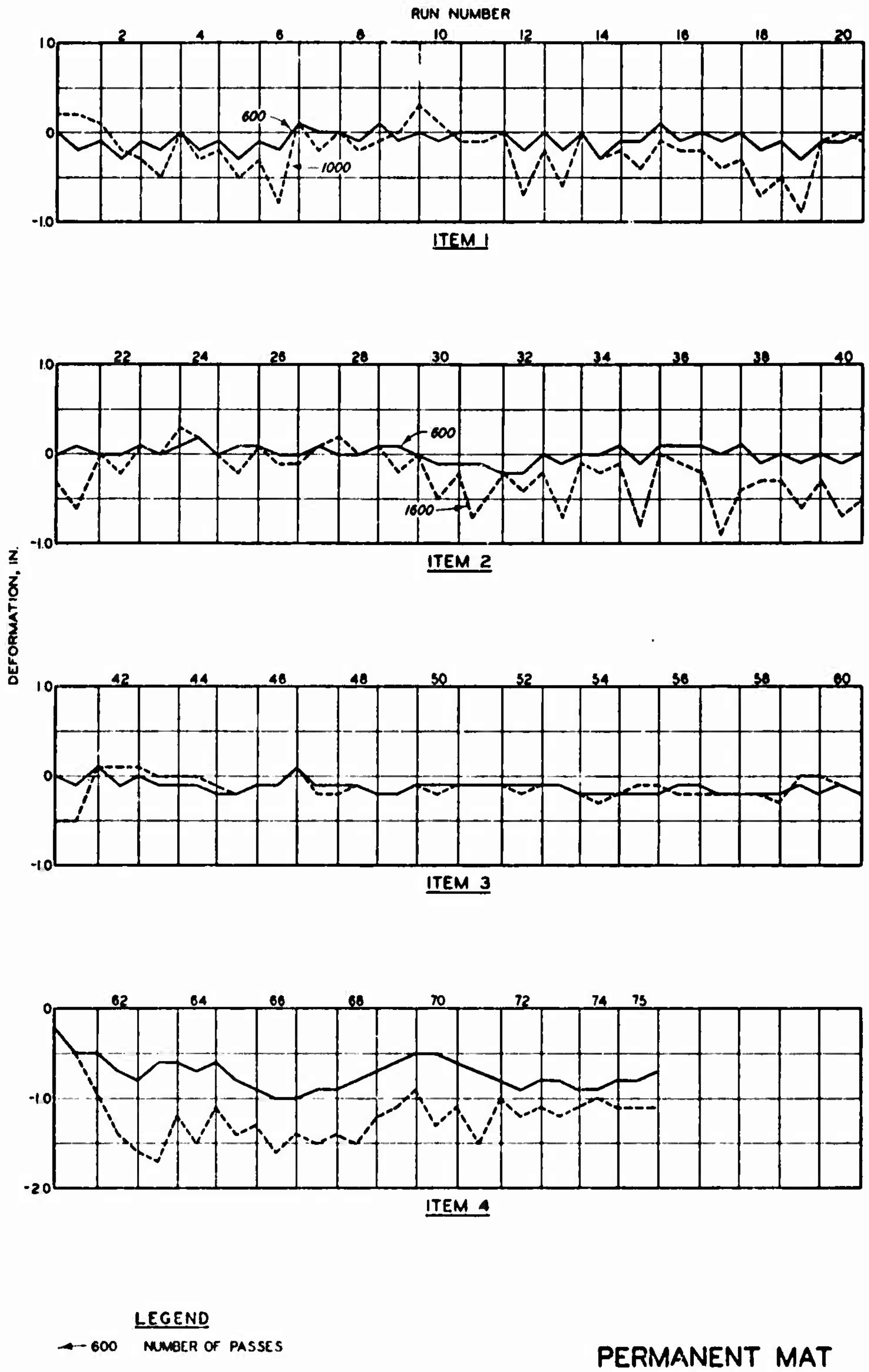
PERMANENT MAT DEFORMATION CROSS SECTIONS

TEST LANE 1
UNIFORM-COVERAGE TRAFFIC

PLATE 4



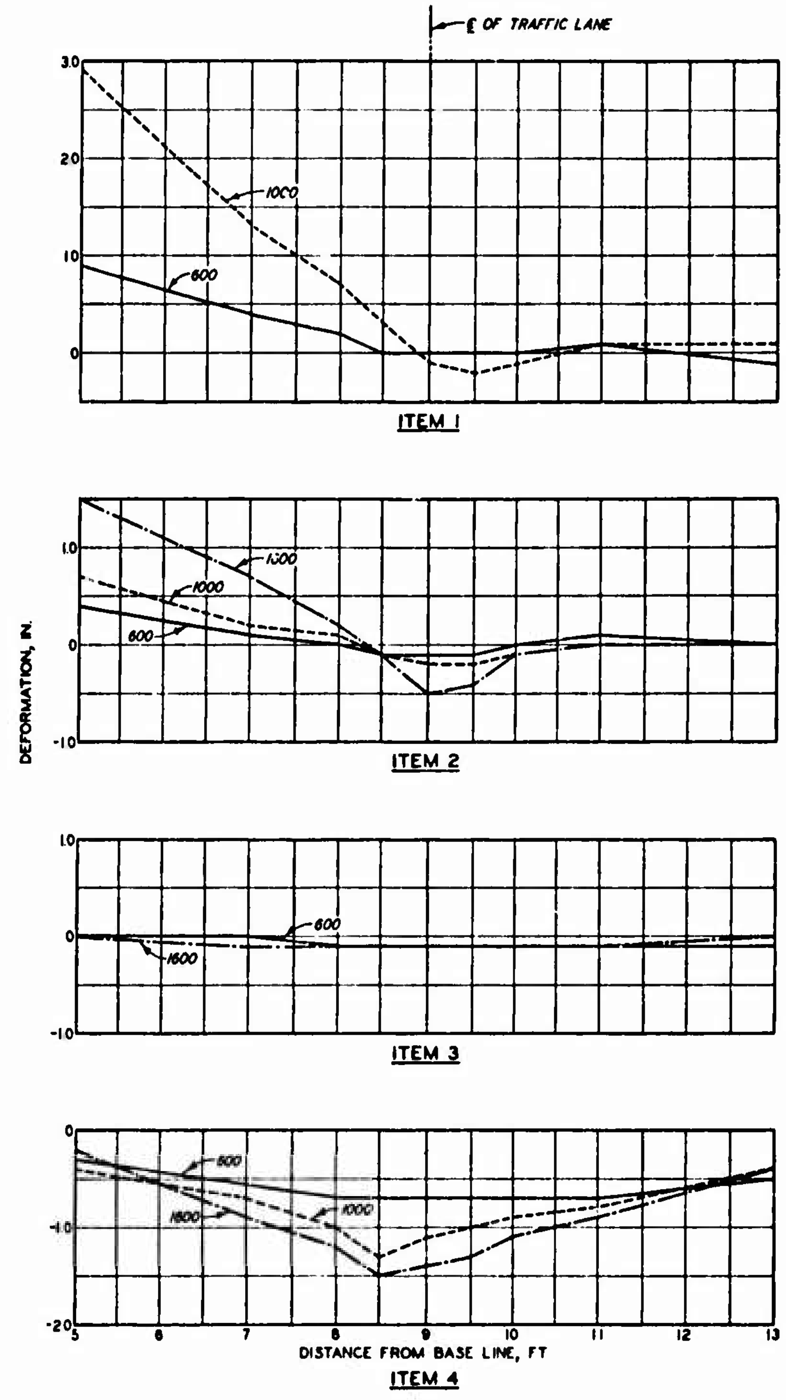
ELASTIC MAT DEFLECTIONS
TEST LANE 1
UNIFORM-COVERAGE TRAFFIC



PERMANENT MAT
DEFORMATION PROFILE

TEST LANE 2
SINGLE-LINE TRAFFIC

PLATE 6

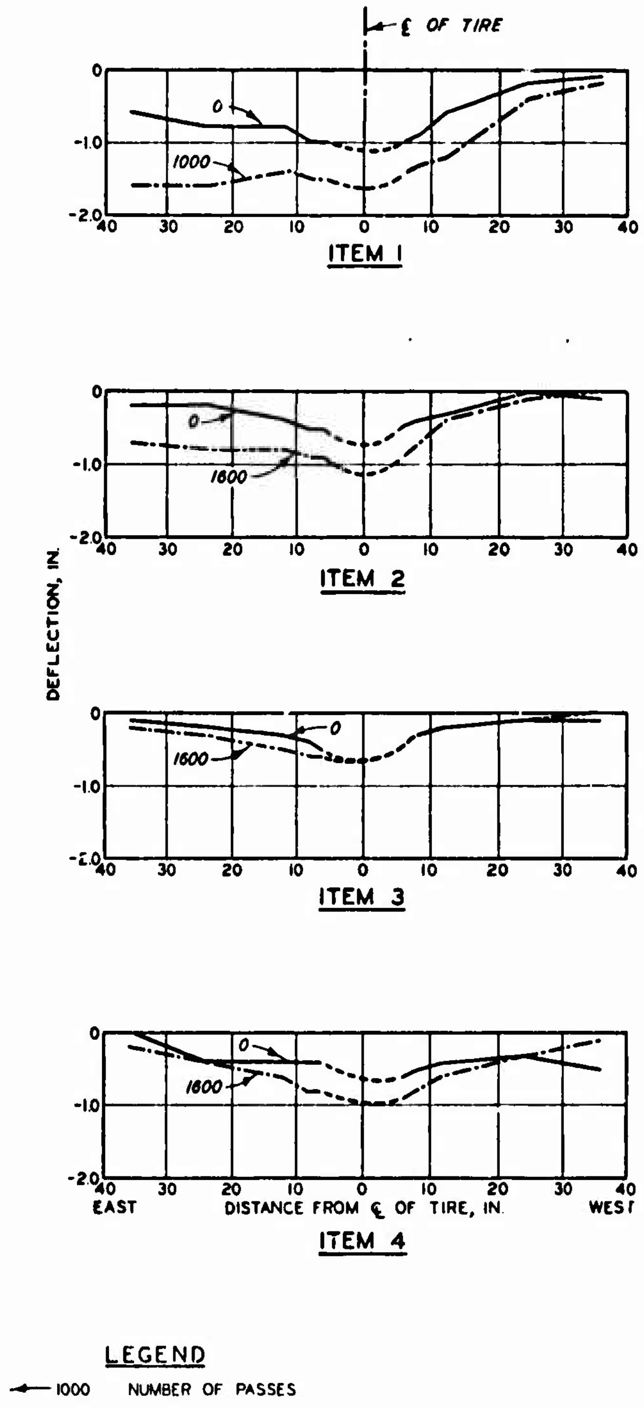


LEGEND

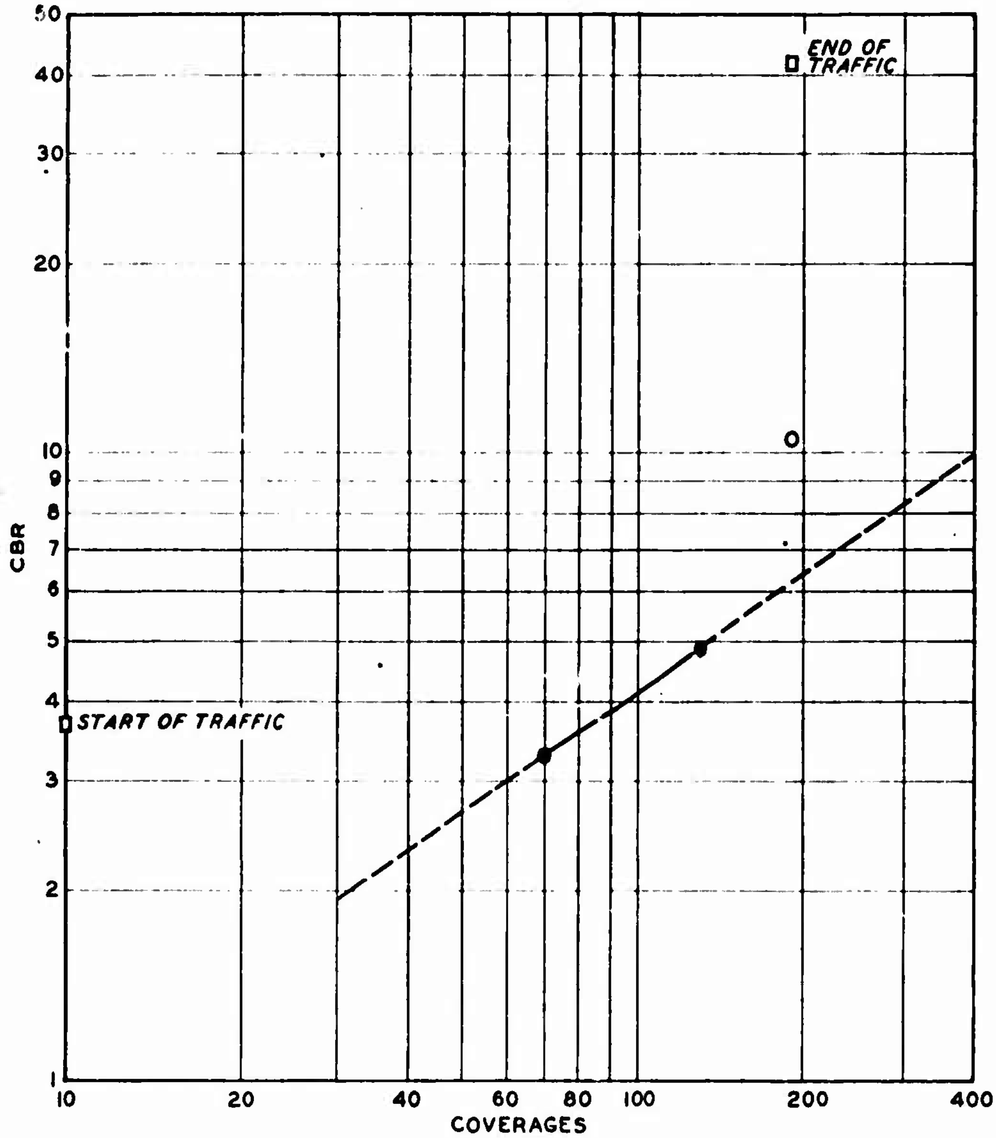
←600 NUMBER OF PASSES

PERMANENT MAT
DEFORMATION CROSS SECTIONS

TEST LANE 2
SINGLE-LINE TRAFFIC



ELASTIC MAT DEFLECTIONS
TEST LANE 2
SINGLE-LINE TRAFFIC



LEGEND

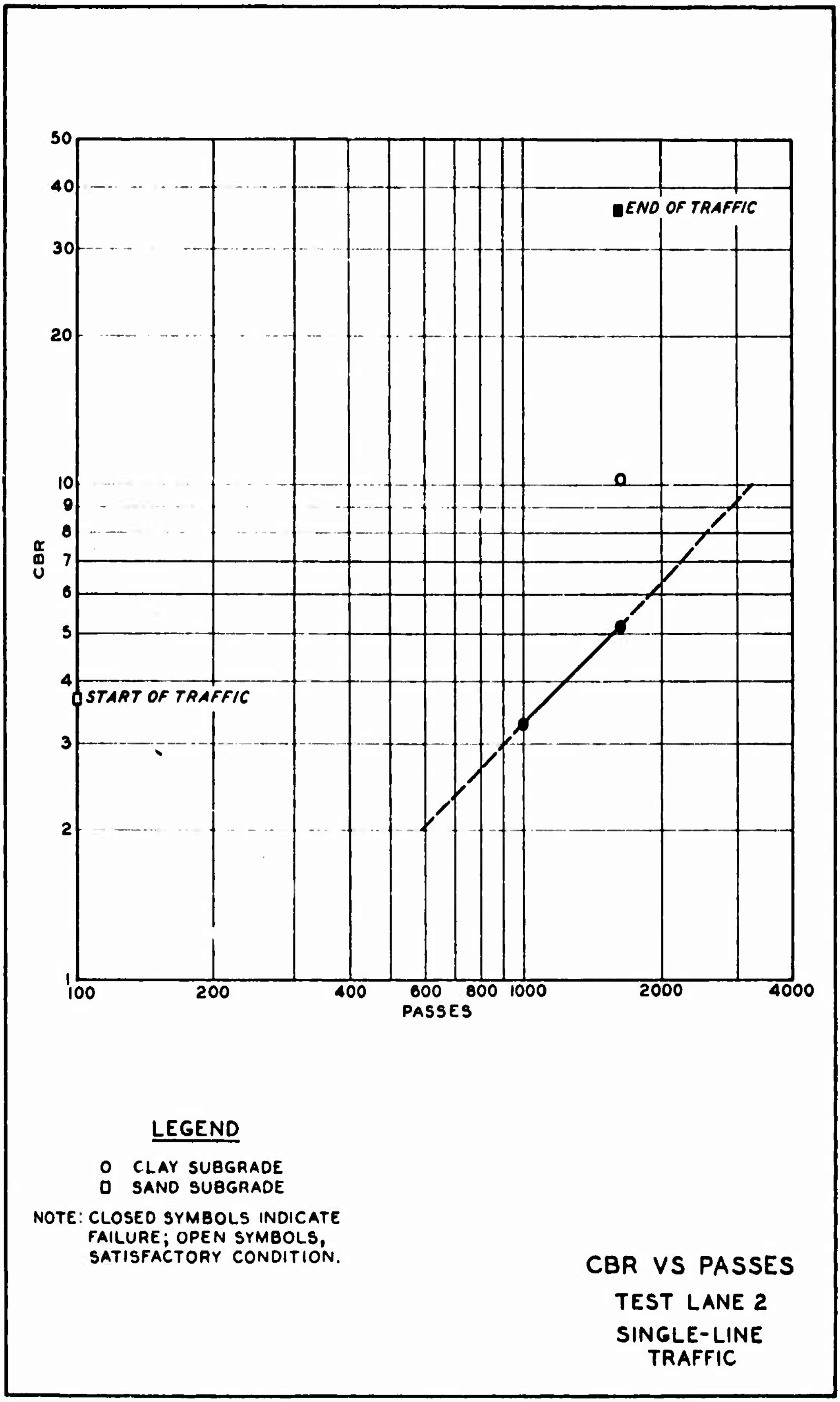
O CLAY SUBGRADE
□ SAND SUBGRADE

NOTE: CLOSED SYMBOLS INDICATE FAILURE; OPEN SYMBOLS, SATISFACTORY CONDITION.

CBR VS COVERAGES

TEST LANE I

UNIFORM-COVERAGE TRAFFIC



50
40
30
20
10
9
8
7
6
5
4
3
2
1
CBR
END OF TRAFFIC
START OF TRAFFIC
100
200
400
600
800
1000
2000
4000
PASSES
LEGEND
O CLAY SUBGRADE
▢ SAND SUBGRADE
NOTE: CLOSED SYMBOLS INDICATE FAILURE; OPEN SYMBOLS, SATISFACTORY CONDITION.
CBR VS PASSES
TEST LANE 2
SINGLE-LINE TRAFFIC